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13. ABSTRACT

This report documents the Dynamic Planning model developed as part of the third phase of the Integrated Facilities Requirements Study (IFRS).

In Phase I, two analytic submodels were developed. The first, a Logistics Support Requirements Generator, estimates personnel, aircraft, and fuel requirements for each phase of undergraduate pilot training at the Naval Air Training Command (NATRACOM). The second, a Pacing Facilities Requirements submodel, calculates facility requirements for each phase of training.

The purpose of the Phase II study was to develop a preliminary total systems IFRS management planning tool (including the two submodels developed in Phase I, as well as Base Loading, Facilities Excess/Deficiency, and Total Cost submodels), and automate the model so that it provides quick, accurate, and relevant information for use in the decision-making process. This Static IFRS model has been in continuous operation since March 1970.

The purpose of the Phase III study was to refine the Static IFRS model and to expand the IFRS concept by developing three additional planning tools for use by Navy decision-makers as follows:

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- Dynamic planning tool
- Optimization model; AND
- Fleet Readiness Training Squadron planning tool.

The Dynamic planning tool simulates the undergraduate pilot training program on a weekly basis whereas the Static IFRS assumes an even annual flow of students. The Optimization model has two segments - a PTR Maximizer that calculates the maximum annual pilot training rate (PTR) possible for a given facilities inventory and a MCON Minimizer that calculates the minimum facility cost phase-to-base assignment for a desired PTR. The Fleet Readiness Training (FRT) model provides planning information for the readiness training squadrons and is designed similarly to the Static IFRS model. The Phase III documentation consists of the following four reports:

- The Integrated Facilities Requirements Study (IFRS) Phase III, ORI TR 645
- Development of the Automated Dynamic Model for the Integrated Facilities Requirements Study (IFRS) Phase III, ORI TR 646
- Development of the Optimization Model for the Integrated Facilities Requirements Study (IFRS) Phase III, ORI TR 647
- Development of the Fleet Air Readiness Training Model for the Integrated Facilities Requirements Study (IFRS) Phase III, ORI TR 648.

This report documents the Dynamic model. Volume I contains a Summary of the Dynamic model and the functional relationships employed. Volume II contains the User's Manual stating how to use the tool. Volume III contains a listing of the computer programs in the Programmer's Manual.

OPERATIONS RESEARCH, Inc.

SILVER SPRING, MARYLAND

Development of the Automated Dynamic Model for the Integrated Facilities Requirements Study (IFRS)

Volume I - Summary of the Dynamic Management Planning Tool

31 March 1971

Prepared under Contract N00025-67-C-0031 ~~(NBy-78672)~~
for the Naval Engineering Command
Department of the Navy
Washington, D.C.

FOREWORD

This report documents the Dynamic planning model developed as part of the third phase of the Integrated Facilities Requirements Study (IFRS). It has been prepared for the Systems Analysis Division of the Office of the Assistant Commander for Facilities Planning (Code 20), Naval Facilities Engineering Command (NAVFAC), Department of the Navy, as part of Contract N00025-67-C-0031 (NBy-78672) awarded to Operations Research, Inc., in June 1970.

In Phase I, two analytic submodels were developed. The first, a Logistics Support Requirements Generator, estimates personnel, aircraft, and fuel requirements for each phase of undergraduate pilot training at the Naval Air Training Command (NATRACOM). The second, a Pacing Facilities Requirements submodel, calculates facility requirements for each phase of training.

The purpose of the Phase II study was to develop a preliminary total systems IFRS management planning tool (including the two submodels developed in Phase I, as well as Base Loading, Facilities Excess/Deficiency, and Total Cost submodels), and automate the model so that it provides quick, accurate, and relevant information for use in the decision-making process. This Static IFRS model has been in continuous operation since March 1970.

The purpose of the Phase III study was to refine the Static IFRS model and to expand the IFRS concept by developing three additional planning tools for use by Navy decision-makers as follows:

- Dynamic planning tool
- Optimization model
- Fleet Readiness Training Squadron planning tool.

The Dynamic planning tool simulates the undergraduate pilot training program on a weekly basis whereas the Static IFRS assumes an even annual flow of students. The Optimization model has two segments—a PTR Maximizer that calculates the maximum annual pilot training rate (PTR) possible for a given facilities inventory and a MCON Minimizer that calculates the minimum facility cost phase-to-base assignment for a desired PTR. The Fleet Readiness Training (FRT) model provides planning information for the readiness training squadrons and is designed similarly to the Static IFRS model. The Phase III documentation consists of the following four reports:

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- Development of the Fleet Air Readiness Training Model for the Integrated Facilities Requirements Study (IFRS) Phase III, ORI TR 648.

This report documents the Dynamic model. Volume I contains a summary of the Dynamic model and the functional relationships employed. Volume II contains the User's Manual stating how to use the planning tool. Volume III contains a listing of the computer programs in the Programmer's Manual.

These IFRS models were developed and programmed by the staff members of the Economic Analysis Division of Operations Research, Inc., under the direction of Dr. William J. Leininger, vice president and division director, and Thomas N. Kyle, program director. The project team members included R.J. Craig, M.C. Fisk, W. Liggett, F. McCoy, R. Messalle, and R. Yockman.

Mr. Dennis Whang of the Systems Analysis Division of Facilities Planning was contract monitor for NAVFAC. In addition, valuable assistance was provided by many other Navy personnel including, in particular, those in the Office of the Staff Civil Engineer and the Training/Plans Division of the Naval Air Training Command, the Aviation Training Division of the Chief of Naval Operations, and in the Systems Analysis Division of NAVFAC. The authors gratefully acknowledge the contributions made by all of these people to the development of the IFRS models.

SUMMARY

This report documents the Dynamic planning tool developed as part of the third phase of the Integrated Facilities Requirements Study (IFRS). The objective of this task is to develop an automated management planning tool that provides the Navy decision-maker with relevant planning information based on the weekly operations of the undergraduate pilot training program.

This model essentially expands the capability of the Static IFRS model into a detailed operational tool. However, this Dynamic model extends and amplifies management capabilities well beyond the point where the Static IFRS model stopped. The Dynamic model replicates the movement of aircraft, instructors, and students on a weekly basis. These resources and facilities are the factors management can control in the training program.

The Dynamic model consists of the following four modules:

- Current Status
- Student Input
- Student Flow
- Shock.

<u>Current Status Module.</u> The purpose of this module is to enter those data that define the present status of each training phase for the current week. These data include aircraft inventory, instructor inventory, student load, and student output.

<u>Student Input Module.</u> The purpose of this module is to calculate the number of students entering the pilot training program on a weekly, monthly, or quarterly basis.

Student Flow Module. The purpose of this module is to calculate the student load, student output, student attrites, aircraft utilization, and instructor utilization for each training phase and week of analysis.

Shock Module. The purpose of the Shock Module is to provide the manager with a means of changing, or shocking, many of the planning factors entered into the student flow module.

The manager has the option to enter the Static IFRS model to determine facility requirements and costs. The flexibility built into the model permits the user to enter the model at several points and also provides a large selection of output options.

These modules are sequentially related and the output of each is printed by the time-share terminal for use by the decision-maker and is automatically entered as input data to one or more successive modules.

The Dynamic model is programmed and is presently operational on a time-share computer system. The computer programs are written in a conversational mode which permits the decision-maker to easily enter his own input data and use the model without knowledge of the FORTRAN programming language. The use of the Dynamic planning tool by Navy decision-makers will benefit the pilot training program by enhancing effective management in the following ways:

- Provides quick, accurate, and relevant information concerning the weekly operations of the undergraduate pilot training program
- Calculates weekly student input requirements as a function of future year pilot training rates
- Identifies potential bottlenecks in training programs
- Facilitates efficient utilization of resources
- Frees management from making voluminous routine calculations
- Provides the capability to test and analyze the consequences of alternative decisions on a common basis.

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I. INTRODUCTION

OBJECTIVE

1.1 The objective of this study is to develop an automated management planning tool that provides the Navy decision-maker with relevant planning information based on the weekly operations of the undergraduate pilot training program. This new planning tool will become one of the series of management tools developed under the Integrated Facilities Requirements Study (IFRS) and must:

- Provide the manager with a weekly analyses period[1/]
- Be capable of calculating weekly student input requirements as a function of future year pilot training rates (PTR)
- Be able to identify bottlenecks in the training program
- Be able to identify the underutilization of aircraft and instructors
- Provide the manager with a means of analyzing various courses of action concerning how changes in aircraft inventories, weather, syllabus requirements, etc., affect the training program
- Be programmed in a time-share conversational mode
- Be flexible so that it will continue to be of use to management.

1/ The Static IFRS model assumes an even annual flow of all students.

Illustrative Factors Considered

1.2 Students enter and graduates leave the pilot training program each week. If there is a large buildup of students, more facilities—BOQs, family housing, messing facilities, etc.,—are required; aircraft and instructor utilizations must increase if weather permits, etc., in an attempt to drive the student load down to a more acceptable or average level. Facilities, as well as other resources have a maximum utilization, and the manager strives to avoid over-utilization if at all possible. In order to maintain an even flow of students throughout the pilot training program, the students, aircraft, instructors, and facilities must be available in the proper proportions. This is an extremely difficult task since many factors affect the training program.

1.3 The Dynamic model is designed to provide the manager with answers to a multitude of "what if" questions concerning how weekly changes in the student load, student input, aircraft (inventory, availability, utilization, hours per student, etc.), instructors (inventory, availability, utilization, hours per student), weather, phase duration, etc., affect the operations of the pilot training program and the resources either used or consumed. Use of the Dynamic model will enable the decision-maker to anticipate and assess weekly fluctuations based on either historical planning factors or actual data as required by the analysis at hand. He can also use the model to determine the weekly student input required to ensure that the required number of students will graduate in the proper time period.

STUDY END PRODUCT

1.4 The end product of this effort is a management planning tool that is currently operational on a time-sharing computer system and two volumes of relevant documentation. The model consists of a series of computer programs and several interrelated data files which constitute an economical and easy-to-use planning tool. The use of a time-sharing computer system ensures that answers are available quickly as required by management. Furthermore, the Dynamic model is written in a conversational language which permits much interaction with the user and permits a large number of alternatives to be studied in great depth. The documentation clearly describes the methodology employed, how to use the model, and the computer programs included.

SIGNIFICANT CONTRIBUTIONS OF DYNAMIC MODEL

1.5 The Dynamic model extends and amplifies management capabilities well beyond the point where the Static IFRS model stopped. Aircraft, instructors, students, and facilities are the resources by which the manager can control the

training process in the short- and long-run. The Dynamic model replicates the utilization of these key variables on a weekly basis. The flexibility built into the model permits the user to enter the model at any of several points and also provides a large selection of output options. It is presently anticipated that the Aviation Training Division of the Chief of Naval Operations (CNO) will be the primary user of the weekly student input determination part of the model. The Training/Plans Division, which is responsible for the operation of CNATRA's pilot training program, will be the primary user of the resource impact portion of the Dynamic model.

II. OVERVIEW OF THE DYNAMIC MANAGEMENT PLANNING TOOL

INTRODUCTION

2.1 The Dynamic model is a new planning tool that essentially replicates the weekly operations of the Navy's undergraduate pilot training program by simulating them on a time-share computer system. It was designed specifically to assist the decision-maker in managing the complex pilot training program.

2.2 Initially the pilot training production processes had to be identified with the inputs, required resources, constraints and limitations, student flow process, and outputs clearly defined. Next this production process was simulated on a time-share computer system by developing the appropriate functional relationships, pertinent planning factors and computer programs.

2.3 The following paragraphs include a discussion of the present pilot training system and the automated Dynamic model.

PILOT TRAINING PRODUCTION PROCESS

2.4 NATRACOM provides the necessary undergraduate pilot training which a student must successfully complete prior to receiving his wings as a qualified Naval aviator (i.e., graduating as a pilot). This undergraduate pilot training program consists of a series of separate but related training phases through which a student must progress until he graduates as a qualified pilot. Presently there are 15 different training phases conducted at 8 different naval air stations (NAS) in Florida, Texas, and Mississippi.

2.5 This pilot training program is a complex process which can be viewed as a production process as shown in Figure 2.1.

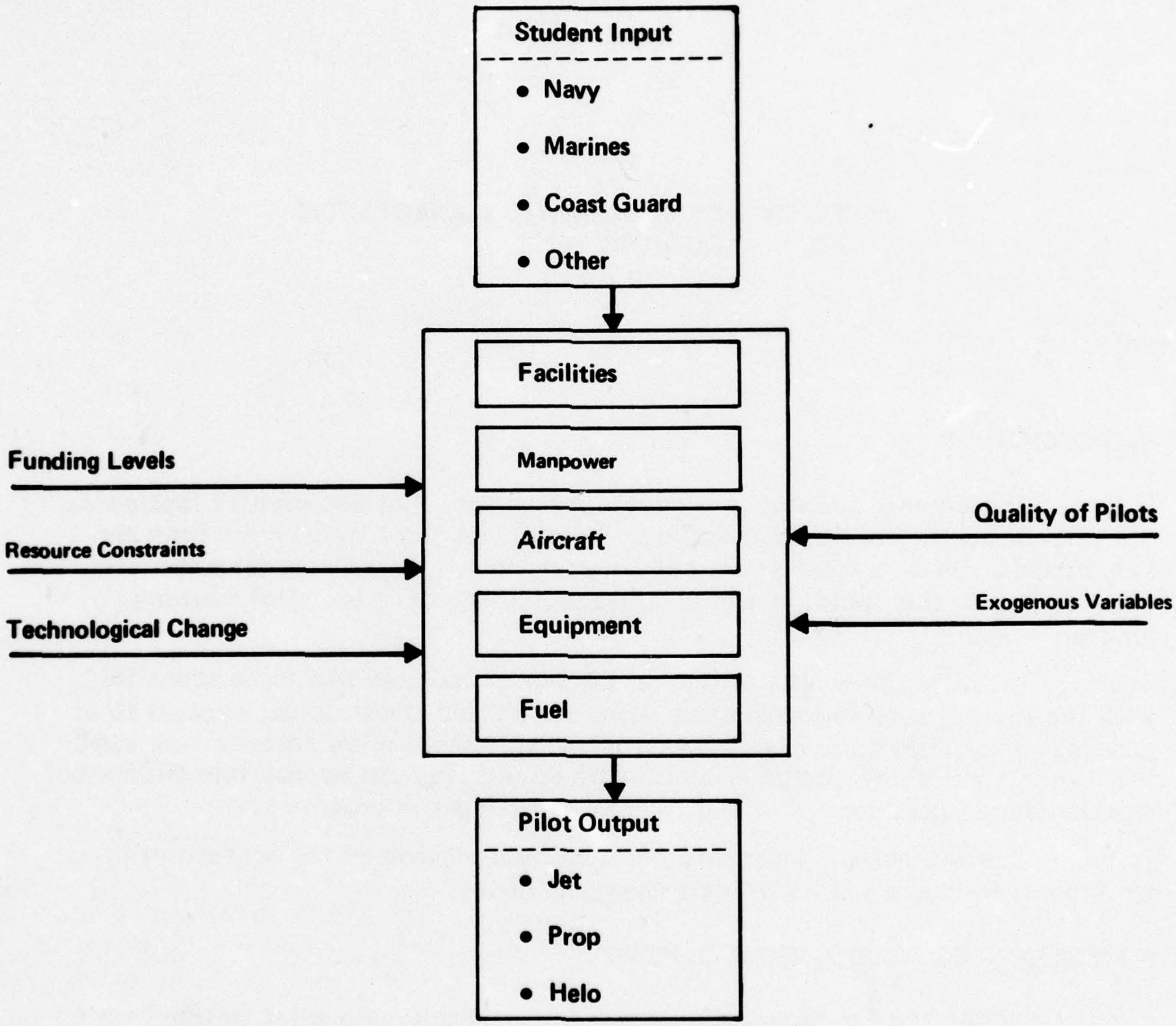

FIGURE 2.1. PILOT TRAINING PRODUCTION PROCESS

2.6 As shown in the top block of Figure 2.1. students from various backgrounds enter the training program. The resources either used or consumed by these students during the training (production) process are illustrated in the center block. However, this training is subject to certain constraints and limitations as illustrated by the arrows pointing toward the production process. The output (i.e., product) from this process is a trained naval aviator as shown in the third block. This training process is discussed in more detail below.

Students Leaving

2.7 One must know what is being trained and thus the output of the training system is discussed first. The output of the pilot training program is a naval aviator (i.e., pilot). Once a student satisfactorily completes the flight and academic requirements, he is qualified as a pilot in one of three aircraft types—jet, propeller (prop), or helicopter (helo)—and is assigned to the fleet aircraft. The proportion of jet, prop, and helo students graduating in a year is called the MIX and the total number to graduate in a year is called the pilot training rate (PTR).

Student Input to Pilot Training Program

2.8 The pilot training program receives new students almost every week throughout the year (i.e., approximately one class per week for 50 weeks). In general, NATRACOM receives students from four different sources:

- Navy officer
- Navy Aviation Officer Candidate (AOC)
- Marines
- Coast Guard/foreign.

2.9 The total number received in a year is determined by the desired annual output or PTR. Due to the variation in background and skill levels of each source, each has its own unique attrition rate and thus the student input must be greater than the student output.

2.10 Navy Officer Student Source. The first source, Navy officer, contains men who are currently commissioned Navy officers, many of whom are recent graduates of the Naval Academy, a university ROTC program, or the Navy Officers Candidate School. Generally, the magnitude of this student source is known approximately 1 year prior to entering NATRACOM. However, the greatest influx corresponds to the conventional college graduation months, i.e., January and June.

2.11 Navy AOC Student Source. The AOC student is not a commissioned officer when he enters the training program. Therefore, the first requirement he must fulfill is to complete the officer training. The magnitude of this student source is determined by the difference between the projected Navy officer output and the total Navy annual pilot requirement.

2.12 Marine Student Source. Marine students are commissioned officers and the weekly number entering the pilot training program is generally known several months in advance.

2.13 Coast Guard/Foreign Student Source. This student source generally does not require officer training. The number of these students entering the pilot training program is small and is known in advance.

Student Flow Through System

2.14 It takes approximately 1 year for a student to complete the requirements to become a pilot. During this time, he must complete the flight and academic requirements of those training phases which are required for the type pilot he is going to be (i.e., jet, prop, or helo). A map that illustrates the path students follow from one phase to another is called the pipeline. The present 15-phase pilot training pipeline is illustrated in Figure 2.2. The specific flight and academic requirements of each phase are defined by a training syllabus. The particular sequence of phases that a student passes through and the training time required are determined by two factors—the student source and the type of pilot desired.

2.15 Time Required to Train Students. Since the length of time required to complete a training phase is unique to each phase, the total time required to train a particular student source in a particular type of aircraft is approximately 1 calendar year, varying from an average high of 64 weeks to an average low of 46 weeks. Table 2.1 illustrates how this average time to train is computed for the jet, prop, and helo pilots by student sources. A 2-week travel time must be added for jet students to travel between Florida, Mississippi and Texas and 1 week for prop students to travel between Florida and Texas.

2.16 This variation in the time required to complete training is very important to the manager who must train a specific number of pilots in a 12-month period. In fact, the Navy is committed to train a specific number of pilots within a fiscal year (i.e., the annual pilot training rate or PTR). Due to the length of time required for training, the students who graduate in a fiscal year, must enter the NATRACOM approximately 1 year prior to graduation. For example, the jet student takes between 59 and 64 weeks to graduate depending on whether or not he must attend officer school.

2.17 The typical time span covered by students who will graduate in FY 1973 is illustrated by the slanted area in Figure 2.3. The solid lines indicate the time period limits for AOC students while the broken lines indicate the time limits for Navy officer students. For the purpose of this illustration, it is assumed that the jet, prop, and helo students are separately identified when they enter the NATRACOM,1/ and all students complete the training in specific average

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1/ In actuality, the type of pilot a student will become is not known until he successfully completes the Primary training phase.

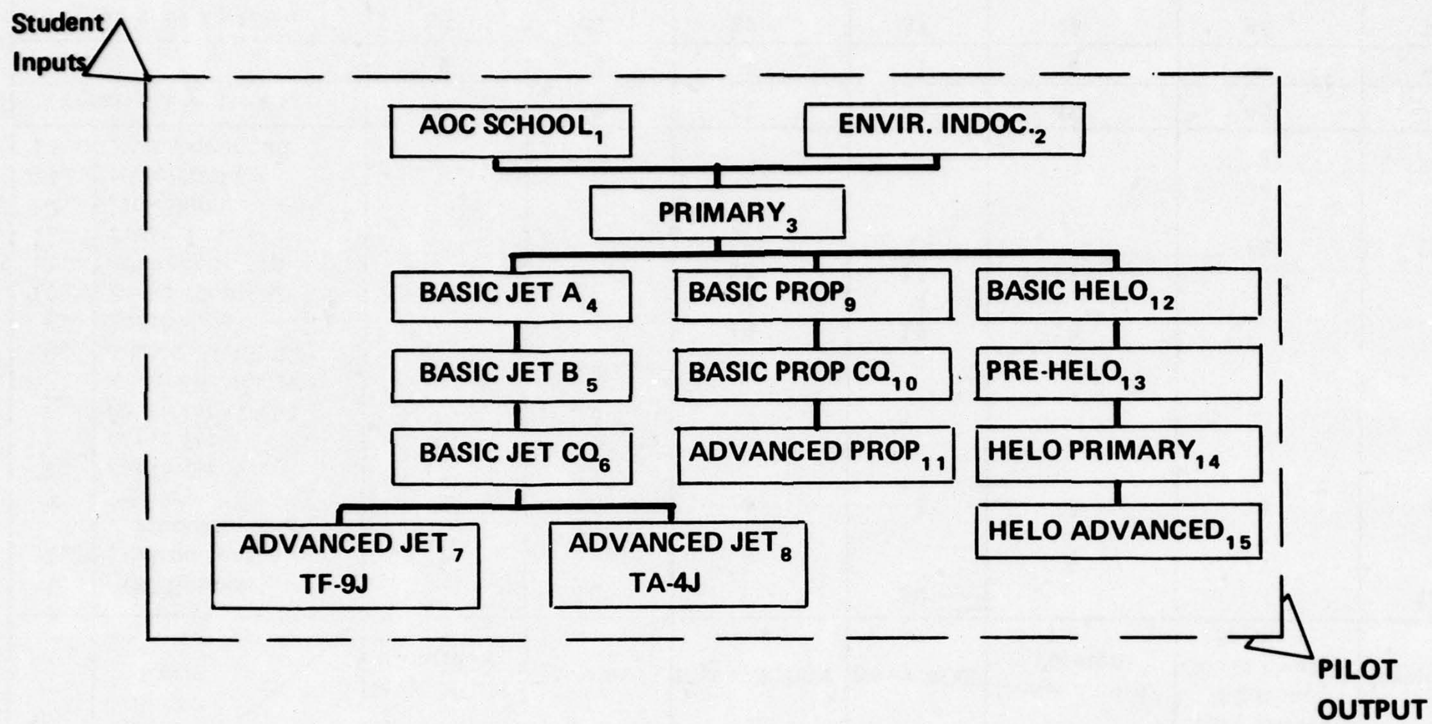

FIGURE 2.2. PILOT FLOW THROUGH PRODUCTION PROCESS

TABLE 2.1

AVERAGE TIME REQUIRED TO TRAIN PILOTS
(Weeks)

Phase No.	Student Source / Phase Name	Pilot Type of Graduate						
		Jet		Prop			Helo	
		Navy Officer; Marines	Navy AOC	Navy Officer	Navy AOC	Coast Guard/ Foreign	Navy Officer; Marines; Coast Guard/ Foreign	Navy AOC
1.	AOC School		10		10			10
2.	Environment Indoctrination	5		5		5	5	
3.	Primary	6	6	6	6	6	6	6
4.	Basic Jet A	12	12					
5.	Basic Jet B	8	8					
6.	Basic Jet G/CQ	6	6					
7.	Advanced Jet TF*	20	20					
8.	Advanced Jet TA*							
9.	Basic Prop			19	19	19		
10.	Basic Prop CQ			4	4			
11.	Advanced Prop			17	17	17		
12.	Basic Helo						18	18
13.	Pre-Helo						5	5
14.	Helo Primary						4	4
15.	Helo Advanced						8	8
Total phase time		57	62	51	56	47	46	51
Travel		2	2	1	1	1	—	—
Total time to train		59	64	52	57	48	46	51

* A student takes either phase 7 or phase 8.

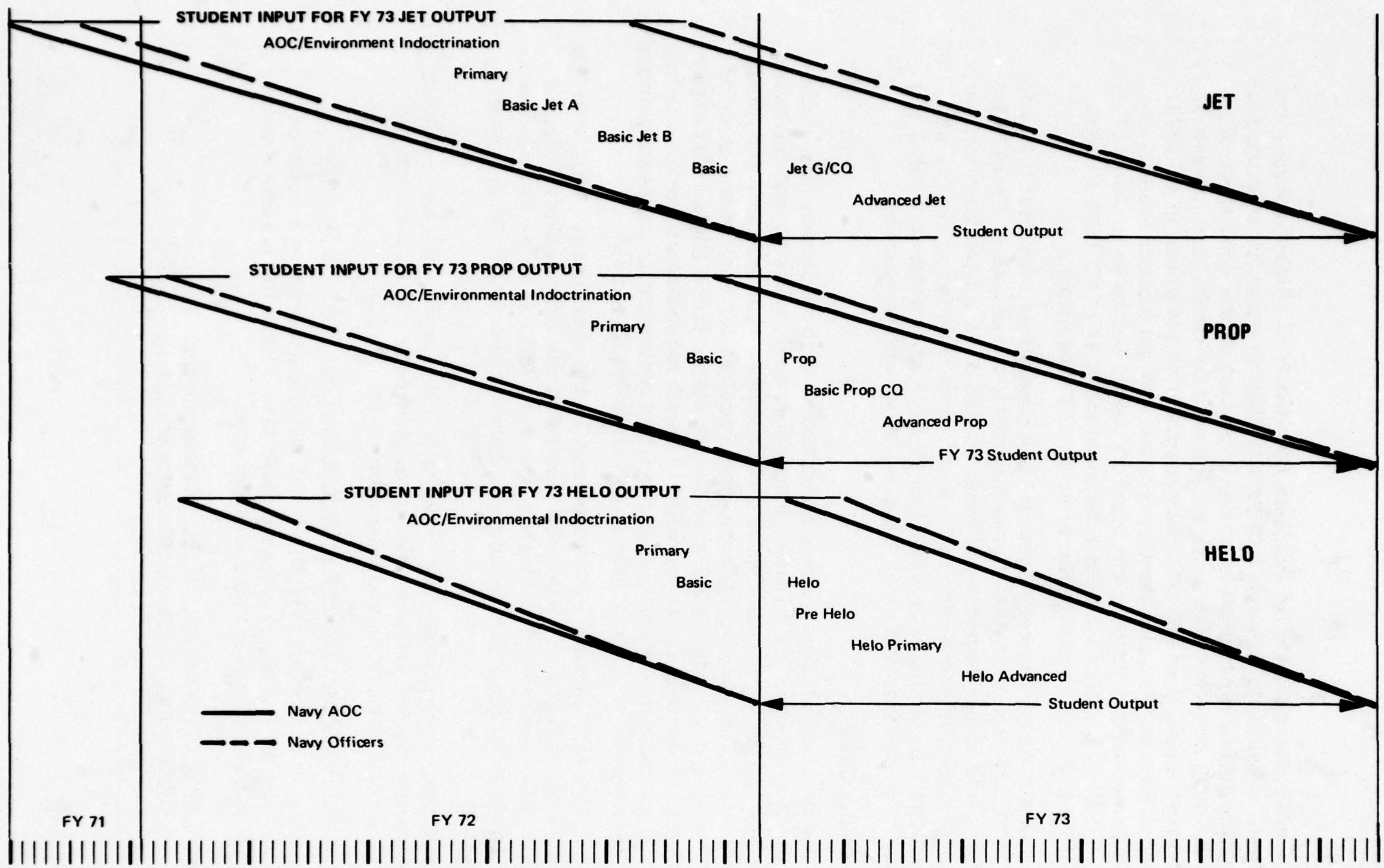

FIGURE 2.3. TIME PERIOD COVERED BY FY 1973 STUDENT OUTPUT

time units. For example, for jet students from the AOC student source, the first students to graduate in week 1 of FY 1973 had to enter the training program 64 weeks before graduation or at the beginning of the 42nd week of FY 1971. All AOC students who enter for the next 52 weeks (i.e., week 42 of FY 1971 through week 41 of FY 1972) may graduate as jet pilots in FY 1973. For a Navy officer jet student, the first students to graduate in week 1 of FY 1973 had to enter the training command 59 weeks before or in week 47 of FY 1971. All Navy officers who enter between week 47 of FY 1971 through week 46 of FY 1972 are then eligible to be FY 1973 jet pilots.

2.18 Since it takes 7 fewer weeks to train prop pilots, the first pilots to graduate in FY 1973 have to enter in the beginning of week 49 of FY 1971 for AOC students and at the beginning of week 2 of FY 1972 for the Navy officer students. The helo students require 13 less weeks than jet students, and thus the first students to graduate in week 1 of FY 1973 must enter in week 3 of FY 1972 for AOC students and week 8 for the Navy officer students.

Resource Requirements

2.19 The primary resources either consumed or utilized during this undergraduate training process are aircraft, manpower, fuel, dollars, and facilities. The manpower resources are divided into instructors, enlisted men, and administrative personnel. The number of instructors required for each phase is determined by the syllabus, which also specifically states those flights that require instructors and those that are flown solo. Aircraft requirements are also defined by the syllabus and account for the unique flight requirements for each training phase. Fuel requirements are a function of aircraft utilization.

2.20 Facility requirements are determined by the total phase, NAS, and the tenant population and aircraft inventory located at the base. Many different types of facilities are required. Some of the more critical areas for pilot training are: runways, aircraft parking aprons, hangars, barracks, BOQs, and family housing.

2.21 The cost of conducting the training program is then the summation of aircraft operating costs, military pay and allowances, military construction costs, annual operations and maintenance costs, etc.

Constraints and Additional Factors Affecting the Pilot Training Program

2.22 As discussed previously, the pilot training program is a complex operation and the pilot training manager must plan within the present environment. Some of the factors he must consider are:

- Students presently in the training program are the nucleus of the graduates over approximately the next 12-month period.

- Students entering the training program in the current year provide the nucleus of graduates in year 2.
- The final type of pilot (i.e., jet, prop, helo) is not known at the time a student enters the program.
- External factors, such as weather, cause various uncertainties in the daily operations of the training phases.
- The amount of available resources may be less than required.

2.23 Current Student Load. Each training phase has a present student load and even if no additional students entered the training process over the next year, the students presently in the pipeline are sufficient to supply all graduates over the next year. The manager is responsible for controlling the pipeline so as to graduate sufficient current enrollees over the year in order to meet his PTR requirement. The student load essentially determines the size of the training program and thus dictates the facility requirements, equipment requirements, costs, etc.

2.24 Current Student Input for the Year. Even though this year's student input is determined by next year's student output (i.e., PTR), next year's student output is not necessarily defined prior to the time this year's new students begin to enter. Consequently, management must set the entrance criteria based on an assumed PTR for next year. Even though this assumed PTR is based on the best information available, the actual number of entering students could be over or under the number actually required by the final PTR. Once the PTR is defined, the manager needs to know how to manage his students, facilities, aircraft, instructors, etc., to meet that defined PTR.

2.25 For example, assume that next year's PTR was not defined and the managers planned to continue the same student input per week as in the past year. Assume further that the final PTR was defined 6 months later to be 25% less than last year's. Management is faced with several problems—in fact, for this example, they are severe problems. The pilot training program has already received two-thirds of its students for the year and the year is only half over (i.e., 50% of planned input is received in first 6 months, but output is cut by 25%). Thus the program must be geared down to a lower tempo for the next 6 months. The student input is a very critical factor and changes in PTR can and do affect student inputs as well as student loads throughout the pilot training system.

2.26 Student Mix (Percent of Jet, Prop, and Helo). At the time a student enters the training program, neither he nor the manager knows what type of

pilot he will become. However, the manager must graduate a specific number of jet, prop, and helo pilots in a fiscal year. Thus he must be constantly aware of how the MIX is evolving in order to graduate the proper number of each type. This problem is very complex since each type of pilot requires a different length of time to complete training.

2.27 External Factors. Assuming that the student input, student load, available aircraft, facilities, instructor, etc., are all in the right proportions and based on the best available planning data, nothing should go wrong with the pilot training program. However, in reality, several factors can cause havoc to a well-managed program. For example, a hurricane completely stops the training in the Pensacola area for 2 weeks; repair parts for older aircraft become scarce and their utilization must be increased; an undefined mechanical failure has resulted in grounding all certain type aircraft for an undefined length of time; illness has resulted in fewer available instructors, etc.

2.28 Limited Resources. Like all production processes, NATRACOM's training phases have a limited supply of resources and each phase must operate within these constraints. Some of the constraints within which a phase must operate were shown in Figure 2.1. The aircraft inventory is often less than adequate. Therefore, either the available aircraft must be carefully scheduled to meet these demands or the student output must be reduced. The number of available instructors may not be exactly what is required. The current facilities inventory may be insufficient to support the desired training level. Limited funds may result in reduced aircraft flight hours, manpower, or facility construction. The introduction of a new training aircraft may result in the development of a new training syllabus and the formation of a new squadron.

Manager's Responsibility

2.29 Many of the major factors affecting the undergraduate pilot training program have been discussed in this section. The manager can change certain factors but can only react to others. To determine the best course of action for each situation he must be able to assess the implications resulting from each change and analyze these results on paper so he can minimize the cost of the training program. Generally, the manager wants to utilize the resources and train the students in an orderly manner by maintaining a smooth flow of students and thus avoiding excessively high or low utilization of resources. The following section discusses the Dynamic planning tool that was specifically designed to assist the manager in this complex environment.

THE AUTOMATED MODULES OF THE DYNAMIC MANAGEMENT PLANNING TOOL

2.30 The automated Dynamic management planning tool consists of a series of computer programs and related data files linked together to replicate the weekly operations of the Navy's undergraduate pilot training program. These

computer programs are divided into four logical components or modules as shown in Figure 2.4. The current status module defines the number of aircraft, number of instructors, student loads, and student output for each training phase. The student input module calculates the weekly student input required to produce a desired weekly output. Finally, the student flow module calculates the student load, student output, student attrites, aircraft utilization, and instructor utilization for each phase and week based on the data entered in the three preceding modules. The shock module provides the manager with the capability to change the critical planning factors by week and phase.

2.31 If the manager desires to determine facility requirements, facility excess/deficiencies, and total systems cost, he then directly enters the Static IFRS[2/] model as shown. The output of each module is printed by the time-share terminal and is automatically entered into subsequent modules as necessary. This section includes a discussion of the inputs required, the methodology employed, the outputs received and special features of each module.

Current Status Module

2.32 The purpose of the current status module is to enter those data that define the present status or loading of each training phase for the current week or the first week of the analysis.

2.33 Inputs. The inputs that are required for each training phase include:

- Student load or number of students on board
- Student output
- Aircraft inventory
- Instructor inventory.

These data may be obtained directly from the Weekly Aviation Statistical Reports (WASR) and entered at the time-share terminal. The manager uses those data that define the week prior to the first week of operation for the Dynamic simulation. For instance, if his analysis period is for the next quarter, he enters the WASR information as of the end of the last week. The student loads that are entered provide the nucleus of the graduates over the next year. Once these current status data are entered into the computer, the manager can change them quickly (on either a temporary or permanent basis) at the time-share terminal. Thus there is no need to enter them each time the model is exercised. Table 2.2 illustrates how the manager enters these data into the computer by typing in the four pieces of data (student load, student output, aircraft inventory, and instructor inventory) for each training phase as shown by the underlined numbers.

[2/] Integrated Facilities Requirements Study Phase II—Development of a Preliminary Automated Total Systems Model, ORI TR 583, 9 February 1970.

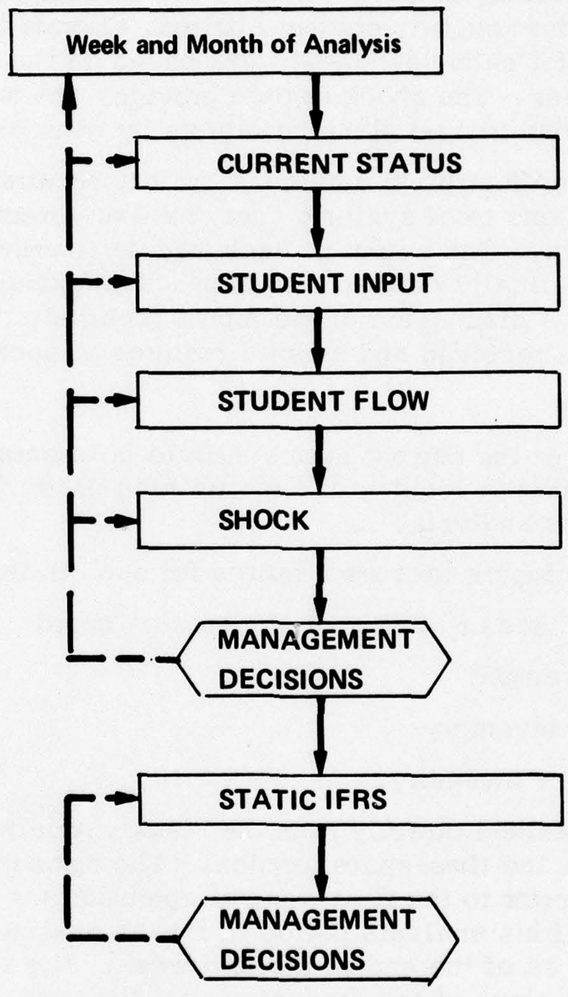

FIGURE 2.4. DYNAMIC SIMULATION OVERVIEW

TABLE 2.2

CURRENT STATUS MODULE

Current Status Inputs Required

	* PHASE NAME	*AIRCRAFT TYPES *	VALUES
1	AOC SCHOOL		?200,15,0,0
2	ENVIRO INDOC		?84,32,0,0
3	PRIMARY	T34B	?450,95,109,136
4	BASIC JET-A	T-2A	?250,18,100,128
5	BASIC JET-B	T2BC	?228,10,103,101
6	B-JET G/CQ	T2BC	?81,28,59,45
7	ADV JET-TF	TF9J	?189,37,153,150
8	ADV JET-TA	TA4J	?213,47,165,175
9	BASIC PROP	T28C	?375,16,101,94
10	B-PROP CQ	T28C	?70,17,14,8
11	ADV PROP	TS2A	?225,10 86,103
12	BASIC HELO	T28C	?143,6,132,123
13	PRE HELO	T28C	?35,8,22,27
14	HELO PRIM	TH57	?80,12,27,30
15	HELO ADV	TH1L	?100,8,68,76

Printout of Current Status

	* PHASE NAME	*A/C *TYPE	*STUDENTS* *ON BOARD*	STUDENT* OUTPUT	NUMBER * *AIRCRAFT*	NUMBER * INSTRS *
1	AOC SCHOOL		200.0	15.0	0.0	0.0
2	ENVIRO INDOC		84.0	32.0	0.0	0.0
3	PRIMARY	T34B	450.0	95.0	109.0	136.0
4	BASIC JET-A	T-2A	250.0	18.0	100.0	128.0
5	BASIC JET-B	T2BC	228.0	10.0	103.0	101.0
6	B-JET G/CQ	T2BC	81.0	28.0	59.0	45.0
7	ADV JET-TF	TF9J	189.0	37.0	153.0	150.0
8	ADV JET-TA	TA4J	213.0	47.0	165.0	175.0
9	BASIC PROP	T28C	375.0	16.0	101.0	94.0
10	B-PROP CQ	T28C	70.0	17.0	14.0	8.0
11	ADV PROP	TS2A	225.0	10.0	86.0	103.0
12	BASIC HELO	T28C	143.0	6.0	132.0	123.0
13	PRE HELO	T28C	35.0	8.0	22.0	27.0
14	HELO PRIM	TH57	80.0	12.0	27.0	30.0
15	HELO ADV	TH1L	100.0	8.0	68.0	76.0

These data are then stored until changed by the manager. When the manager requests a copy of these data, they are printed as shown in the lower section of Table 2.2. Note that the computer does not change these data in the current status module, but supplies them to subsequent modules as necessary.

Student Input Module

2.34 The purpose of the student input module is to calculate the number of students entering the pilot training program on a weekly basis. There are two entry phases in the present training program—AOC School and Environmental Indoctrination or phases 1 and 2. Each student source has a specific entry phase as shown below:

Student Source	Entry Phase
Navy officer	2
Navy AOC	1
Marine	2
Coast Guard/foreign	2

2.35 Inputs. The manager can choose to enter data into this module by one of two means:

- Directly enter weekly student input by entry phase
- Calculate weekly student input based on a desired future pilot output (i.e., PTR and student source).

2.36 If the weekly student input has previously been defined, the manager may choose to enter those quantities directly into the model. Often the exact expected student input to the entry phases for the next quarter or 6-month period is known and thus he has the capability to enter these known quantities.

2.37 To calculate the weekly student input requirements the following data must be entered:

- The pipeline or the path that a student follows from his entry phase until graduation
- Attrition rate by phase and student source
- Average length of time required to successfully complete each training phase in weeks
- Travel time required between phases in weeks
- The cumulative student output desired for each terminal (i.e., advanced) phase and student source.

Since the pipeline, the attrition rate, length of phases, and travel time do not change frequently, these data are stored in the computer and need only be entered when the manager desires to change them. A computer listing of the present length of each phase is available to the manager as shown in Table 2.3. However, the weekly, monthly, quarterly, or annual pilot output changes often and these values must be entered for each student source for each analysis.

2.38 General Methodology. The methodology employed in the student input module initially calculates the weekly student input required to graduate the specific output by source from each terminal phase. Thus the student input required in week 1, less total attrites (i.e., from all phases) equals the student output in some future week (ranging from week 46 to 64 depending on pilot type and source). Secondly, it sums student inputs required (by source) over all terminal phases to calculate total student inputs required by source and week. Finally it sums student input by entry phase and week.

2.39 Output. The output of the student input module consists of three segments:

- Weekly student inputs by source required to graduate a specified number of pilots for each terminal phase in time period entered
- A summary of total student inputs required by week for each student source
- A summary of total students entering each entry phase by week.

The manager selects the three printouts he desires, For the last two outputs, he can choose only those weeks that he wants to see rather than print the entire summary.

2.40 Illustrative Example. To illustrate the use of this module, assume that the manager wants to know the weekly number of students who must enter the training program in weeks 1-26 in order to produce 212 Navy officers and 107 Marine jet pilots in a 6-month period (i.e., between weeks 59 and 84 of the Dynamic simulation). The cumulative desired student output by time period appears at the top of Table 2.4. These data are entered into the planning tool as shown by the underlined parts in the center of Table 2.4. In this example, both Navy officers and Marines follow identical pipelines and can therefore be entered together. Finally at the bottom of Table 2.4, the information received from the student input module is shown. This shows the number of students by source who must enter in those time periods (i.e., weeks 1-26) to produce jet pilots in weeks 59-84. If the manager considered other student sources, this process is repeated for each student source and terminal phase. Then the summary printouts are available. Table 2.5 illustrates the two types of printouts available. The weekly student inputs by student source appear at the top while the student input by entry phase appears in the lower part. In

TABLE 2.3

PRINTOUT OF LENGTH OF TRAINING PHASES

1	AOC SCHOOL	10
2	ENVIRO INDOC	5
3	PRIMARY	6
4	BASIC JET-A	12
5	BASIC JET-B	8
6	B-JET G/CQ	6
7	ADV JET-TF	20
8	ADV JET-TA	20
9	BASIC PROP	19
10	B-PROP CQ	4
11	ADV PROP	17
12	BASIC HELO	18
13	PRE HELO	5
14	HELO PRIM	4
15	HELO ADV	8

TABLE 2.4

SAMPLE INPUT DATA REQUIRED FOR
ADVANCED JET TA-4 PHASE OF TRAINING
(Average Length of Training = 59 Weeks)

Student Input for Week	Desired Student Output in Week	Cumulative Student Output by Student Source	
		Navy Officer	Marines
1	59	10	5
2	60	18	9
3	61	27	12
5	63	42	20
6	64	47	25
7-16	74	132	60
17-26	84	212	107

Required Data Entries

```
ENTER PTR OUTPUT FOR TERMINAL PHASE  7: ADV JET-TF
THE RELATED SOURCES FOR THIS PHASE ARE:
   1   NAVY OFFICER
   2   MARINE
STUDENT OUTPUT RANGE(WEEKS) 59 TO 158
ENTER  3 VALUES ?59,10,5
NEXT?60,18,9
NEXT?61,27,12
NEXT?63,42,20
NEXT?64,47,25
NEXT?74,132,60
NEXT?84,212,107
NEXT?0,0,0
```

Information Received from Model

```
*** WEEKLY STUDENT INPUT--ADV JET-TF    ***
 WEEKS              NAVY OFF     MARINE
 1 TO  1             12.26        5.98
 2 TO  2              9.81        4.78
 3 TO  3             11.04        3.59
 4 TO  5              9.20        4.78
 6 TO  6              6.13        5.98
 7 TO 16             10.42        4.19
17 TO 26              9.81        5.62
27 TO 00              9.81        5.62
```

TABLE 2.5

WEEKLY STUDENT INPUT

Required by Source

CUMULATIVE STUDENT INPUT

WEEK	*NAVY OFFICER	*NAVY - AOC	*MARINE	*C-GRD & FOR.*
1	21.79	26.09	11.61	3.39
2	21.79	26.09	11.61	3.39
3	21.79	26.09	11.61	3.39
4	21.79	26.09	11.61	3.39
5	21.79	26.09	11.61	3.39
6	20.92	26.09	11.91	3.39
7	20.92	26.09	11.91	3.39
8	20.92	24.96	11.91	3.39
9	20.92	24.96	11.91	3.39
10	20.92	24.96	11.91	3.39
11	20.92	24.96	11.91	3.39
12	20.92	24.96	11.91	3.39
13	20.05	24.96	11.91	3.39
14	20.05	24.72	11.91	3.39
15	20.05	24.72	11.91	3.39
16	20.05	24.72	11.91	3.39
17	20.05	24.72	11.91	3.30
18	20.05	24.72	11.91	3.30
19	19.86	24.72	11.63	3.26
20	19.86	24.72	11.63	3.26
21	19.86	24.72	11.63	3.26
22	19.86	24.72	11.63	3.26
23	19.86	24.72	11.63	3.26
24	19.86	24.72	11.63	3.26
25	19.86	24.72	11.63	3.26
26	19.86	24.72	11.63	3.26

Required by Entry Phase

WEEK	*PHASE 2	*PHASE 1
1	36.8	26.1
2	36.8	26.1
3	36.8	26.1
4	36.8	26.1
5	36.8	26.1
6	36.2	26.1
7	36.2	26.1
8	36.2	25.0
9	36.2	25.0
10	36.2	25.0
11	36.2	25.0
12	36.2	25.0
13	35.4	25.0
14	35.4	24.7
15	35.4	24.7
16	35.4	24.7
17	35.3	24.7
18	35.3	24.7
19	34.7	24.7
20	34.7	24.7
21	34.7	24.7
22	34.7	24.7
23	34.7	24.7
24	34.7	24.7
25	34.7	24.7
26	34.7	24.7

this case, the user has the option to select those weeks of interest. If these weekly student inputs are saved in the computer, they are automatically updated (i.e., once a week is over, the new students for week 1 have entered the system and the previous week 2 students become the new week 1 students) at the manager's discretion.

Student Flow Module

2.41 The purpose of the student flow module is to calculate the student load, student output, student attrites, aircraft utilization and instructor utilization for each training phase and each week of the analysis.

2.42 Inputs. The data required for this module are grouped into six segments.

- Planning factors that define each phase of training
- Pipeline or definition of the flow process from entry to terminal phases
- Percent of MIX for branch points in the pipeline
- First week and month of simulation
- Number of weeks to be simulated
- Student input and student load information from student input and current status modules.

2.43 Initially, the following planning factors that define each phase of training are entered for each phase.

- Length of phase in weeks
- Average attrition rate for all student sources
- Days scheduled to fly per week
- Aircraft utilization (operational) in hours per day assuming perfect weather
- Instructor utilization (operational) in hours per day assuming perfect weather
- Aircraft flight hours required per student output (including overhead hours)
- Instructor hours required per student output (including overhead hours)
- Aircraft availability or percent of assigned aircraft in operational condition

- Instructor availability or percent of assigned effective instructors available to instruct students
- Monthly weather factors or percent of flyable weather by aircraft type.

2.44 The next input is the pipeline or sequence in which a student passes through the training phases. These above data are permanently stored in the computer until the decision-maker wants to change them; thus there is no need to re-enter these data each time the model is used.

2.45 The manager must enter an initial mix or distribution of students when one phase leads to two or more phases. As shown in the sample printout in Table 2.6, he must enter those data underlined to define the distribution of students at branch points in the pipeline. In that illustration, phase 3 leads to phases 4, 9, and 12 or Basic Jet A, Basic Prop, and Basic Helo. The manager in this case wants to divide the graduates of Phase 3 among the following phases by 43.5% to Basic Jet A, 24% to Basic Prop, and 32.5% to Basic Helo. This MIX must be entered each time the model is run and the user has ample opportunity to change it throughout the program.

2.46 In order to use the proper monthly weather factors, the user must enter the week and month number corresponding to week 1 of the dynamic simulation as shown in the lower half of Table 2.6. In this case, the user stated that the first week of the simulation was the third week in April or 3, 4 as underlined. Once this is entered, the computer prints out the number of the first week of the simulation for each month of the year as shown.

2.47 Next the manager must enter the number of weeks included in his simulation run. He can simulate for 26 weeks at a time and the total time period covered is unlimited but it is recommended that the total time period not exceed 2 years. Table 2.6 illustrates how the manager enters his period of analysis. In this example, he wants to simulate weeks 1 through 11 as shown by the underlined numbers

2.48 The final data required to run this module include those previously discussed under the current status module and those from the student input module which appear below:

- Weekly student input by entry phase
- Student load at the beginning of week 1 of the simulation for each training phase
- Student output prior to the beginning of week 1 for each phase
- Aircraft inventory for each phase
- Instructor inventory for each phase.

TABLE 2.6

STUDENT INPUT MODULE INPUTS

Enter MIX

```
ENTER AN INITIAL MIX FØR THE FØLLØWING BRANCH PHASES
THE VALUES ARE PERCENTAGES(100%=1.0) GØING TØ THE FØLLØWING PHASES

PHASE   3 : PRIMARY        LEADS TØ
PHASES    4  9 12
INPUT   3 VALUES?.435,.24,.325

PHASE   6 : B-JET G/CQ     LEADS TØ
PHASES    7   8
INPUT   2 VALUES?.45,.55

PHASE   9 : BASIC PRØP     LEADS TØ
PHASES   10 11
INPUT   2 VALUES?.968,.032
```

Enter Week 1 of Analysis Period

```
ENTER WEEK ØF MØNTH (1-5) AND MØNTH (1-12)
THAT CØRRESPØNDS TØ WEEK 1 FØR THIS RUN(XX,XX)?3,4
```

MØNTH NØ.	4	5	6	7	8	9	10	11	12	1	2	3	4
WEEK NØ.	1	4	8	12	17	21	25	30	34	38	43	47	51

Enter Time Period for Simulation

```
GIVE FIRST AND LAST WEEK NUMBER FØR
THIS DYNAMIC SIMULATIØN (XX,XX)?1,11
```

The manager has the option of changing these data at various points in the model.

2.49 General Methodology. The methodology employed in this student flow module is based on the methodology used in the Phase II Static IFRS model and is divided into two steps. First, the student flow process must be determined and second, the magnitude of the student output must be calculated. The module operates 1 week at a time and flows students from entry to terminal phases. An incidence matrix is developed within the model based on the pipeline information. This incidence matrix along with the specified MIX at branch points defines which phases students flow to once they complete a phase. For example, the incidence matrix states that the Primary phase graduates have three possible phases to flow into—Basic Jet A, Basic Prop, and Basic Helo. The specified MIX states the percentage breakdown going to each of the three phases. Thus in this example, the weekly student output of the Primary phase becomes next week's student input to the three following phases. In this way the student inputs to a phase are defined by the student outputs of prior phases with attrition occurring only within a phase.

2.50 Next the magnitude of the student outputs of each phase is calculated based on the assumption of an even flow within a phase (i.e., in a 10-week phase, a maximum of 10% of the students graduate each week). The student output of each phase is calculated three different ways to determine the maximum possible output based on aircraft inventory, instructor inventory, and student load. The model then takes the minimum student output of the above three methods of calculating student output to be the actual output for that phase and week. Thus if the aircraft inventory will support 20 graduates per week, the instructor inventory will support 17 graduates per week, and the size of the student load supports 25 graduates per week, the model determines that instructors are constraining and thus graduates 17 students that week. Based on this "actual" student output, the "actual" aircraft and instructor utilizations are calculated. This process is repeated for every phase in each week of the simulation period.

2.51 Output. The output of this module consists of the following:

- Student load
- Student output
- Student attrites
- Aircraft utilization
- Instructor utilization.

These data are provided for each phase and week. Various print options are available to the user at this time. He may elect to print the "phase output" for selected weeks as shown in the top of Table 2.7 for the Primary phase and weeks 1-10, or an average weekly figure for Primary over the 10-week period

as shown. Similarly, he may want to see all phases for week 8 as shown in the bottom of Table 2.7, or he may select particular phases. Thus the user has many print options available to meet his analytic requirements.

Shock Module

2.52 The purpose of the shock module is to provide the manager with a means of changing, or shocking, most of the data entered into the student flow module.

2.53 Input. The manager has the capability to shock 14 different variables that are used in the student flow module as shown in Table 2.8. He can shock any phase and week with any variable. To perform this shock process, he must enter four numbers—the week number, the phase number, the shock variable number, and the new value of the shock variable—as shown by the instructions in Table 2.9. At the bottom of Table 2.9, the underlined numbers indicate how aircraft utilization can be shocked for phase 3 in week 2; how student output can be shocked in phase 8 in week 4; etc. Essentially the number and types of shocks are unlimited. The precise ones used depend on the analytic needs.

2.54 General Methodology. The shock module replaces the standard planning factor in the week and phase specified and then the student flow module operates as previously discussed.

2.55 Output. The printouts of this module are the same as the student flow module previously discussed.

Flexibility of the Dynamic Model

2.56 The automation of the Dynamic model was completed with emphasis on providing the Navy with a flexible planning tool that would calculate answers to a multitude of management questions concerning present as well as future pilot training programs. This flexibility was built into the Dynamic model by writing the computer programs in a conversational mode. The result is a model which asks the decision-maker various questions to which he must reply before the model proceeds with its calculation. The data files take maximum advantage of the Static IFRS data files. The manager can easily change data files at the time-share terminal without any knowledge of the FORTRAN programming language. For example, when a new phase of training is added or an old one deleted, the manager needs only to enter the appropriate planning factors in the data files.

2.57 The manager can also select a variety of printout options depending on his specific needs. He can enter the Dynamic model at several points so there is no need to re-enter all inputs each time the model is run. Finally, the Dynamic model has been set up to include the naval flying officer (NFO) segment of training at a later date.

TABLE 2.7

PRINT OPTIONS OF STUDENT FLOW MODULE

Phase Output—Actual for Weeks 1-10

PHASE PRIMARY

WEEK PERIOD	STUD. ONBOARD	STUD. OUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
WEEK 1	436.7	51.5	8.8	4.99	4.18
WEEK 2	406.1	68.7	8.6	4.99	4.18
WEEK 3	395.9	51.5	8.1	4.99	4.18
WEEK 4	364.8	74.5	7.9	4.86	4.07
WEEK 5	352.7	57.7	7.4	4.99	4.18
WEEK 6	342.1	57.7	7.2	4.99	4.18
WEEK 7	355.9	34.4	7.1	5.00	2.49
WEEK 8	347.6	57.0	7.3	4.99	4.18
WEEK 9	370.8	26.2	7.2	5.00	1.92
WEEK 10	363.1	57.0	7.6	4.99	4.18

Phase Output—Average of Weeks 1-10

PHASE PRIMARY

WEEK PERIOD	STUD. ONBOARD	STUD. OUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
1-10	373.5	53.6	7.7	4.98	3.77

WEEKS 8

Time Output

TRAINING PHASE	STUD. ONBOARD	STUD. OUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
AOC SCHOOL	207.9	23.3	1.9		
ENVIRO INDOC	132.0	33.2	0.9		
PRIMARY	374.5	57.0	7.8	4.99	4.18
BASIC JET-A	255.7	22.7	1.6	4.60	3.70
BASIC JET-B	215.8	22.8	0.8	4.46	3.69
B-JET G/CQ	103.3	20.5	0.4	3.65	3.21
ADV JET-TF	182.5	9.4	0.5	4.53	2.76
ADV JET-TA	206.7	10.9	0.5	4.55	2.61
BASIC PROP	359.3	11.1	4.3	4.69	4.22
B-PROP CQ	71.4	11.4	0.1	3.56	3.14
ADV PROP	233.5	11.9	0.3	5.21	3.62
BASIC HELO	192.9	11.5	1.9	3.19	2.89
PRE HELO	41.4	10.4	0.0	3.13	2.99
HELO PRIM	37.4	12.5	0.0	3.98	3.45
HELO ADV	99.6	14.2	0.1	4.69	3.64

TIME OUTPUT DESIRED(Y,N)?NX

TABLE 2.8

LIST OF SHOCK VARIABLES

** THE SHOCK VARIABLES ARE LISTED WITH THEIR RESPECTIVE ACCESS NUMBER AND A CURRENT MAXIMUM VALUE **

1. PHASE ATTRITION RATE (0.196)
2. PHASE DURATION IN WEEKS (20.00)
3. DAYS SCHEDULED TO FLY PER WEEK (4.90)
4. HOURS PER DAY AIRCRAFT UTILIZED PER AIRCRAFT TYPE (5.23)
5. HOURS PER DAY INSTRUCTOR UTILIZED PER AIRCRAFT TYPE (4.44)
6. AVERAGE FLIGHT HOURS TO TRAIN STUDENT PER AIRCRAFT TYPE (205.00)
7. AVERAGE INSTRUCTOR HOURS TO TRAIN STUDENT PER AIRCRAFT TYPE (145.30
8. AIRCRAFT PERCENT AVAILABILITY PER AIRCRAFT TYPE (0.840)
9. INSTRUCTOR PERCENT AVAILABILITY PER AIRCRAFT TYPE (0.770)
10. MONTHLY WEATHER FACTOR PER AIRCRAFT TYPE (0.970)
11. STUDENT INPUT PER WEEK
12. STUDENT OUTPUT PER WEEK
13. NUMBER OF AIRCRAFT(A3 STATUS) PER AIRCRAFT TYPE (165.00)
14. NUMBER OF INSTRUCTORS PER AIRCRAFT TYPE (175.00)

TABLE 2.9

SHOCK MODULE INSTRUCTIONS AND SAMPLE SHOCK ENTRIES

```
* * * SHOCK MODULE INSTRUCTIONS * * *

THE FIRST ENTRY WILL BE THE 3 SHOCK PARAMETERS
WEEK NO., PHASE NO., SHOCK VARIABLE NO. (XX,XX,XX)

THE SECOND ENTRY WILL BE THE VALUE(S) THE SHOCK VARIABLE WILL
ASSUME, DEPENDENT ON THE NUMBER OF AIRCRAFT TYPES(A,B,C).
VALUE,VALUE,VALUE(AAA,BBB,CCC)

* * * SPECIFIC RULES OF SHOCK * * *

1. TO CHANGE A VALUE PREVIOUSLY ENTERED,RETYPE THE PARAMETERS
   AND ENTER A NEW VALUE. A (-99) VALUE ENTRY ELIMINATES THE PARAMETERS.
2. TO CONSIDER THE SHOCK VARIABLE FOR THE ENTIRE PROJECTION
   RANGE, ENTER (0) FOR THE WEEK. A (0) ENTRY FOR THE PHASE INDICATES
   ALL PHASES WILL BE CONSIDERED.

 ENTER SHOCK PARAMETERS(XX,XX,XX)
 TO TERMINATE SHOCK ENTER(0,0,0)?2,3,5

 PRINT THE AIRCRAFT IN THIS PHASE(Y,N)?N
 ENTER 1 SHOCK VALUE?6.0

 ENTER SHOCK PARAMETERS(XX,XX,XX)?4,8,13
 ENTER 1 SHOCK VALUE?25
```

III. THE DYNAMIC MODEL IN THE MANAGEMENT PLANNING PROCESS

3.1 The Dynamic model provides the manager with an extremely powerful tool which can assist him in analyzing a variety of problems. This section discusses how the Dynamic model can be used to solve several typical problems. These examples may seem unnecessarily complex but should prove to be of significant value to the managers of the pilot training program.

PROBLEM 1—DETERMINE WEEKLY STUDENT INPUT REQUIREMENTS FOR FISCAL YEAR 1973 GRADUATES

3.2 Assume the pilot training rate (PTR) for FY 1973 has been established at 2,300 graduates divided among the four student sources and four terminal phases as shown in Table 3.1 . The problem for management is to determine the average weekly student input by source and time period that will produce these 2,300 pilots. The student input module of the Dynamic planning tool was designed to provide answers to this type of problem.

Preparation of Data Input

3.3 Since the length of time required to train a pilot varies by the type (i.e., jet, prop, and helo) as well as student source, as shown in Table 3.2, the recommended starting point to solve this problem is the preparation of a student input time-span chart illustrating the weeks in which each student by source must enter if he is to be considered for graduation as a particular type of pilot in FY 1973.

TABLE 3.1

HYPOTHETICAL FY 1973 PILOT TRAINING RATE
(PTR = 2,300)

Type of Pilot	Terminal Phase Number	Student Source				Total by Type
		Navy Officer	Navy AOC	Marine	Coast Guard/Foreign	
Jet	7	180	180	90	—	1,000
	8	220	220	110	—	
Prop	11	225	225	—	100	550
Helo	15	200	200	300	50	750
Total by source		825	825	500	150	2,300

TABLE 3.2

AVERAGE TIME REQUIRED TO TRAIN PILOTS*
(Weeks)

Type of Pilot	Terminal Phase Number	Student Source			
		Navy Officer	Navy AOC	Marine	Coast Guard/Foreign
Jet	7	59	64	59	—
	8	59	64	59	—
Prop	11	52	57	—	48
Helo	15	46	51	46	46

* Based on Table 2.1 of this volume.

3.4 A sample student input time span chart based on the length of time to train (Table 3.2) is illustrated in Figure 3.1. The week numbers shown are the weeks of the dynamic simulation and range from 1 to 115. As shown for this example, weeks 1-11 of the simulation are actually the last 11 weeks of FY 1971, the next 52 weeks (i.e., weeks 12 through 63) define the end weeks of FY 1972, and the last 52 weeks (i.e., 64 through 115) are the end weeks of FY 1973. (Note that all FY 1973 pilots graduate in this final 52 week period.) The 115-week span of this simulation is determined by the greatest length of time required to train a student source as a type of pilot. In this example, the AOC students who graduate as jet pilots define the simulation time span (i.e., 63 weeks prior to FY 1973 and 52 weeks in FY 1973). Each student input span is 52 weeks. The two top lines indicate that students who are going to be FY 1973 jet pilots, must enter between weeks 1 through 52 for Navy AOC and weeks 6 through 57 for Navy officers and Marines. In this example, AOC jet students require the longest training period—64 weeks—thus men in this student source who enter NATRACOM between weeks 1 and 52 of the simulation period and graduate as jet pilots[1/] will graduate in FY 1973 (i.e., the first FY 1973 graduates are in week 64 and continue through week 115 of simulation).

3.5 Navy AOC prop pilots take 57 weeks to complete training and thus enter between weeks 8 and 59. Similarly, Navy officer prop students take 52 weeks and enter between weeks 13 and 64 while Coast Guard/foreign prop students require a 47-week course (i.e., they skip carrier qualifications) and enter between weeks 17 and 68.

3.6 Finally the potential Navy AOC helo pilots enter the NATRACOM between weeks 14 and 65 of the simulation, since the length of their training is 51 weeks. Navy officers, Marines, and Coast Guard/foreign students require an average of 47 weeks to graduate as helo pilots, and they enter between weeks 19 and 70 as shown.

3.7 This time span chart essentially illustrates that students who enter between the beginning and end points may graduate as that type of pilot in FY 1973. An important fact is that the only students who are certain to be FY 1973 pilots are those who enter between weeks 19 and 52. This is because students who enter between weeks 1 and 19 could be either FY 1972 or FY 1973 graduates. Similarly, those who enter between weeks 53 and 70 could be either FY 1973 or FY 1974 graduates.

1/ This entry period pertains only to jet graduates in FY 1973, because all AOC students do not necessarily graduate as jet pilots.

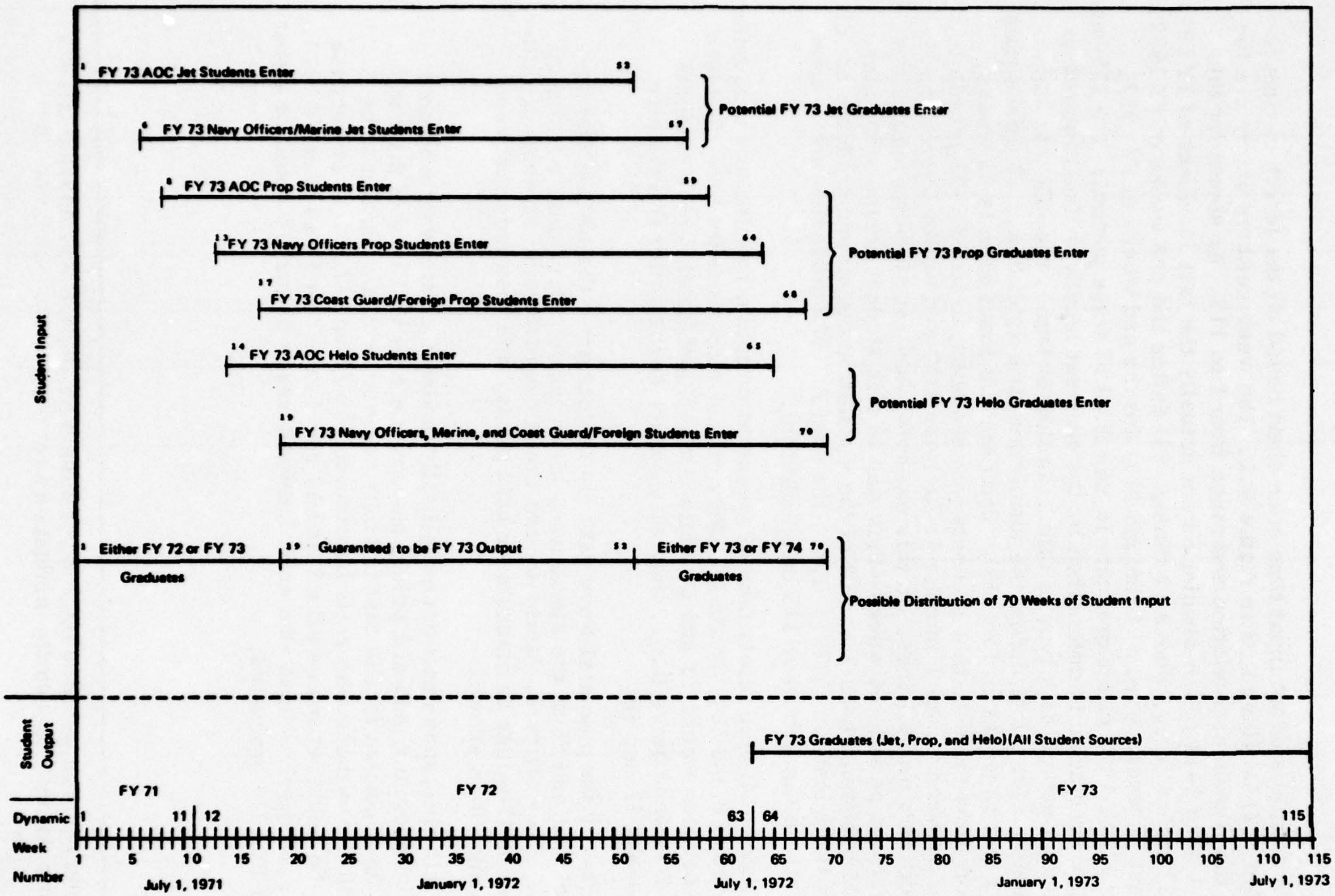

FIGURE 3.1. TOTAL STUDENT INPUT TIME SPAN COVERED BY STUDENT SOURCE AND TYPE PILOT FOR FY 1973 GRADUATES

Entering Data Into Student Input Module of Dynamic Model

3.8 Once the above chart is prepared, the manager enters the PTR data into the time-share terminal for each type of pilot and student source. Table 3.3 illustrates this entry procedure for the jet students in phase 8.

3.9 As shown at point A in the printout, the length of time required for Navy officers and Marines to become jet pilots is 59 weeks. Since the model requires the user to enter cumulative PTR, the user must first enter the remaining FY 1972 graduates between weeks 59 and 63. In this example, 22 Navy officers and 10 Marines were to graduate in the last 5 weeks of FY 1972. Next, by week 115 (i.e., the end of FY 1973) 242 (220 in FY 1973 and 22 in FY 1972) Navy officer students and 120 Marine students will graduate from this advanced jet phase. The Dynamic model then prints out the student input required by week to produce this output. This weekly average of 5.19 Navy officers and 2.53 Marines must enter the training program between weeks 6 and 57 of the simulation in order to graduate 220 and 110 jet pilots respectively. Those students who must enter to provide the last 5 weeks of FY 1972 graduates appear as weeks 1-5 inputs. Point B of Table 3.3 illustrates the Navy AOC student input calculations. Since the length of training is 64 weeks, the manager needs to enter only the FY 1973 PTR desired in week 115 as shown. The result is then printed as an average of 6.26 new students per week for the first 52 weeks of the simulation. The model assumes the last weekly input remains through 100 weeks unless instructed as shown in this example, (i.e., the same student output was entered for the final week period and no additional student inputs were calculated). After this same process is repeated for each type of pilot and student source, a summary printout of student input by source and week is available to the decision-maker as shown in Table 3.4. Between weeks 1 and 19, the student inputs vary, since these are both FY 1972 and FY 1973 graduates. Between weeks 19 and 52, all students entering are FY 1973 graduates. The student inputs required for FY 1973 pilots begin to taper off after week 52 as shown. The underlined weeks indicate those weeks in which changes occur and correspond to those in Figure 3.1.

PROBLEM 2—ANALYZE FLOW PROCESS BASED ON CURRENT AIRCRAFT AND INSTRUCTOR INVENTORIES

3.10 Assume that the present hypothetical aircraft and instructor inventory are to be used to train all students (i.e., those currently on board at the beginning of week 1 plus new student input defined in Problem 1) starting with week 1 of the simulation. The problem is to determine if the use of these present resources will result in an even flow of students throughout all training phases.

3.11 The Dynamic model was designed to assist management in the analysis of this type of problem. Initially the hypothetical student load, last week's student output, aircraft inventory, and instructor inventory expected as of the beginning of week 1 of the simulation are entered into the Current Status module

TABLE 3.3

STUDENT INPUT MODULE
SAMPLE ENTRY OF PTR AND RESULTANT
WEEKLY STUDENT INPUT

```
A.  ENTER PTR OUTPUT FOR TERMINAL PHASE  8: ADV JET-TA
    THE RELATED SOURCES FOR THIS PHASE ARE:
       1   NAVY OFFICER
       2   MARINE
    STUDENT OUTPUT RANGE(WEEKS) 59 TO 158
    ENTER  3 VALUES ?63,22,10
    NEXT?115,242,120
    NEXT?158,242,120
    NEXT?0,0,0

    *** WEEKLY STUDENT INPUT--ADV JET-TA    ***
     WEEKS          NAVY OFF     MARINE
     1 TO  5          5.40         2.39
     6 TO 57          5.19         2.53
    58 TO 00          0.           0.

    ACCEPTABLE STUDENT INPUT/OUTPUT (Y,N)?Y

B.  ENTER PTR OUTPUT FOR TERMINAL PHASE  8: ADV JET-TA
    THE RELATED SOURCES FOR THIS PHASE ARE:
       1   NAVY - AOC
    STUDENT OUTPUT RANGE(WEEKS) 64 TO 163
    ENTER  2 VALUES ?115,220
    NEXT?163,220
    NEXT?0,0

    *** WEEKLY STUDENT INPUT--ADV JET-TA    ***
     WEEKS          NAVY - A
     1 TO 52          6.26
    53 TO 00          0.

    ACCEPTABLE STUDENT INPUT/OUTPUT (Y,N)?Y
```

TABLE 3.4

WEEKLY STUDENT INPUT REQUIRED

FY 1972 and FY 1973 Graduates

CUMULATIVE STUDENT INPUT

WEEK	*NAVY ØFFICER	*NAVY - AØC	*MARINE	*C-GRD & FØR.*
1	21.79	26.09	11.61	3.39
2	21.79	26.09	11.61	3.39
3	21.79	26.09	11.61	3.39
4	21.79	26.09	11.61	3.39
5	21.79	26.09	11.61	3.39
6	20.92	26.09	11.91	3.39
7	20.92	26.09	11.91	3.39
8	20.92	24.96	11.91	3.39
9	20.92	24.96	11.91	3.39
10	20.92	24.96	11.91	3.39
11	20.92	24.96	11.91	3.39
12	20.92	24.96	11.91	3.39
13	20.05	24.96	11.91	3.39
14	20.05	24.72	11.91	3.39
15	20.05	24.72	11.91	3.39
16	20.05	24.72	11.91	3.39
17	20.05	24.72	11.91	3.30
18	20.05	24.72	11.91	3.30

All FY 1973 Graduates

WEEK	*NAVY ØFFICER	*NAVY - AØC	*MARINE	*C-GRD & FØR.*
19	19.86	24.72	11.63	3.26
20	19.86	24.72	11.63	3.26
21	19.86	24.72	11.63	3.26
22	19.86	24.72	11.63	3.26
23	19.86	24.72	11.63	3.26
24	19.86	24.72	11.63	3.26
25	19.86	24.72	11.63	3.26
26	19.86	24.72	11.63	3.26
27	19.86	24.72	11.63	3.26
28	19.86	24.72	11.63	3.26
29	19.86	24.72	11.63	3.26
30	19.86	24.72	11.63	3.26
31	19.86	24.72	11.63	3.26
32	19.86	24.72	11.63	3.26
33	19.86	24.72	11.63	3.26
34	19.86	24.72	11.63	3.26
35	19.86	24.72	11.63	3.26
36	19.86	24.72	11.63	3.26
37	19.86	24.72	11.63	3.26

TABLE 3.4 (Cont)

38	19.86	24.72	11.63	3.26
39	19.86	24.72	11.63	3.26
40	19.86	24.72	11.63	3.26
41	19.86	24.72	11.63	3.26
42	19.86	24.72	11.63	3.26
43	19.86	24.72	11.63	3.26
44	19.86	24.72	11.63	3.26
45	19.86	24.72	11.63	3.26
46	19.86	24.72	11.63	3.26
47	19.86	24.72	11.63	3.26
48	19.86	24.72	11.63	3.26
49	19.86	24.72	11.63	3.26
50	19.86	24.72	11.63	3.26
51	19.86	24.72	11.63	3.26
52	19.86	24.72	11.63	3.26
53	19.86	13.33	11.63	3.26
54	19.86	13.33	11.63	3.26
55	19.86	13.33	11.63	3.26
56	19.86	13.33	11.63	3.26
57	19.86	13.33	11.63	3.26
58	10.43	13.33	7.03	3.26
59	10.43	13.33	7.03	3.26
60	10.43	6.10	7.03	3.26
61	10.43	6.10	7.03	3.26
62	10.43	6.10	7.03	3.26
63	10.43	6.10	7.03	3.26
64	10.43	6.10	7.03	3.26
65	4.88	6.10	7.03	3.26
66	4.88	0.	7.03	3.26
67	4.88	0.	7.03	3.26
68	4.88	0.	7.03	3.26
69	4.88	0.	7.03	1.09
70	4.88	0.	7.03	1.09
71	0.	0.	0.	0.
72	0.	0.	0.	0.
73	0.	0.	0.	0.
74	0.	0.	0.	0.
75	0.	0.	0.	0.
76	0.	0.	0.	0.
77	0.	0.	0.	0.

as shown in Table 3.5. These values are printed out for later use as shown at bottom of the table. Next the manager must enter the present MIX of students flowing from branch points (e.g., percent of primary output going to jet, prop, and helo) as shown in Table 3.6. Similarly, he must enter the time period of the first week of the simulation. In this example, week 1 is the third week in April 1971 and thus he enters "3,4" as shown in the second half of Table 3.6. The model then prints out the simulation week numbers as a function of months as shown. Therefore week 12 is the first week in July and the beginning of a new fiscal year. Next, the decision-maker runs the Dynamic model for the 115 weeks and requests printouts on a quarterly basis. In this example, the standard planning factors were used and the printouts present the status of each phase as of the end of the quarters through the first quarter of FY 1973 (see Tables 3.7 through 3.9). These printouts were then scanned to identify any drastic increases or decreases in student loads, any consistent underutilization of resources, etc. Several bottlenecks as well as underutilization of resources were identified in the training phases.

3.12 Two phases with problems—Basic Helo and Advanced Prop—will be discussed in more detail. In the case of Basic Helo, the student load was building up at a rapid rate and almost doubled by the end of FY 1972 (see Table 3.10). Both aircraft and instructor utilization were maximum standard values from the planning factors, but the present resources could not accommodate the expected throughput. This simulation run identifies this problem area to the decision-maker in week 1 when there is ample time to make changes to prevent this bottleneck from occurring. For instance, he can increase the number of aircraft and instructors assigned to this phase, increase days flown per week , or increase utilization, etc. On the other hand, as also shown in Table 3.10,the Advanced Prop phase of training posed the opposite type of problem—underutilization of aircraft and instructors as indicated by the decreasing student loads and daily utilizations.

3.13 Many other similar situations were apparent in this dynamic simulation run. For instance, the fact that the Basic Helo phase was holding students for an excessive length of time resulted in the following three helo phases having fewer students and low resource utilizations. All three prop phases showed similar trends. By using the Dynamic model to analyze this problem, the manager can identify his potential problem areas and has ample time to take appropriate corrective actions.

PROBLEM 3—ANALYZE FLOW PROCESS BASED ON NEW AIRCRAFT AND INSTRUCTOR INVENTORIES

3.14 Many problems were apparent to the manager after he conducted the previous analysis. Now he wants to determine what happens if he assumes different aircraft and instructor inventories for each phase. Thus, the manager is trying to determine if this new set of resources will provide an even flow

TABLE 3.5

PROBLEM 2—DATA INPUT TO CURRENT STATUS MODULE

Problem 2—Data Input to Current Status Module

	* PHASE NAME	*AIRCRAFT TYPES	* VALUES
1	AØC SCHØØL		?200,15,0,0
2	ENVIRØ INDØC		?84,32,0,0
3	PRIMARY	T34B	?450,95,118,150
4	BASIC JET-A	T-2A	?250,18,93,120
5	BASIC JET-B	T2BC	?228,10,100,100
6	B-JET G/CQ	T2BC	?81,28,52,43
7	ADV JET-TF	TF9J	?189,37,160,145
8	ADV JET-TA	TA4J	?213,47,135,145
9	BASIC PRØP	T28C	?375,16,170,175
10	B-PRØP CQ	T28C	?70,17,31,24
11	ADV PRØP	TS2A	?225,10,150,195
12	BASIC HELØ	T28C	?143,6,80,75
13	PRE HELØ	T28C	?35,8,17,19
14	HELØ PRIM	TH57	?80,12,38,44
15	HELØ ADV	TH1L	?100,8,69,70

Resultant Printout of Current Status Module

	* PHASE NAME	*A/C *TYPE	*STUDENTS* *ØN BØARD*	STUDENT* ØUTPUT	NUMBER * *AIRCRAFT*	NUMBER * INSTRS *
1	AØC SCHØØL		200.0	15.0	0.0	0.0
2	ENVIRØ INDØC		84.0	32.0	0.0	0.0
3	PRIMARY	T34B	450.0	95.0	118.0	150.0
4	BASIC JET-A	T-2A	250.0	18.0	93.0	120.0
5	BASIC JET-B	T2BC	228.0	10.0	100.0	100.0
6	B-JET G/CQ	T2BC	81.0	28.0	52.0	43.0
7	ADV JET-TF	TF9J	189.0	37.0	160.0	145.0
8	ADV JET-TA	TA4J	213.0	47.0	135.0	145.0
9	BASIC PRØP	T28C	375.0	16.0	170.0	175.0
10	B-PRØP CQ	T28C	70.0	17.0	31.0	24.0
11	ADV PRØP	TS2A	225.0	10.0	150.0	195.0
12	BASIC HELØ	T28C	143.0	6.0	80.0	75.0
13	PRE HELØ	T28C	35.0	8.0	17.0	19.0
14	HELØ PRIM	TH57	80.0	12.0	38.0	44.0
15	HELØ ADV	TH1L	100.0	8.0	69.0	70.0

TABLE 3.6

PROBLEM 2—DATA INPUTS

Enter MIX

```
ENTER AN INITIAL MIX FØR THE FØLLØWING BRANCH PHASES
THE VALUES ARE PERCENTAGES(100%=1.0) GØING TØ THE FØLLØWING PHASES

PHASE   3 : PRIMARY        LEADS TØ
PHASES    4  9 12
INPUT   3 VALUES?.435,.24,.325

PHASE   6 : B-JET G/CQ    LEADS TØ
PHASES    7  8
INPUT   2 VALUES?.45,.55

PHASE   9 : BASIC PRØP    LEADS TØ
PHASES   10 11
INPUT   2 VALUES?.968,.032
```

Enter Week 1 of Simulation

```
ENTER WEEK ØF MØNTH (1-5) AND MØNTH (1-12)
THAT CØRRESPØNDS TØ WEEK 1 FØR THIS RUN(XX,XX)?3,4
```

MØNTH NØ.	4	5	6	7	8	9	10	11	12	1	2	3	4
WEEK NØ.	1	4	8	12	17	21	25	30	34	38	43	47	51
	FY 71			FY 72									

MØNTH NØ.	4	5	6	7	8	9	10	11	12	1	2	3	4
WEEK NØ.	51	56	60	64	69	73	77	82	86	90	95	99	103
	FY 72			FY 73									

TABLE 3.7

DYNAMIC MODEL OUTPUT
PROBLEM 2—STATUS OF ALL TRAINING PHASES

End of FY 1971

WEEKS 11 TØ 11

TRAINING PHASE	STUD. ØNBØARD	STUD. ØUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
AØC SCHØØL	207.2	23.2	1.9		
ENVIRØ INDØC	136.1	34.3	0.9		
PRIMARY	289.8	59.2	6.3	4.79	3.94
BASIC JET-A	301.7	21.1	1.8	4.60	3.67
BASIC JET-B	204.6	22.1	0.7	4.46	3.62
B-JET G/CQ	114.6	18.1	0.4	3.65	2.96
ADV JET-TF	179.4	9.1	0.4	4.19	2.76
ADV JET-TA	220.0	9.4	0.5	4.80	2.72
BASIC PRØP	298.3	16.8	3.6	4.22	3.44
B-PRØP CQ	52.2	17.4	0.1	2.45	1.59
ADV PRØP	264.4	16.5	0.3	4.15	2.65
BASIC HELØ	234.9	10.2	2.2	4.69	4.22
PRE HELØ	40.4	10.1	0.0	3.95	4.14
HELØ PRIM	31.4	10.5	0.0	2.37	1.98
HELØ ADV	96.4	13.8	0.1	4.48	3.83

End of First Quarter FY 1972

WEEKS 24 TØ 24

TRAINING PHASE	STUD. ØNBØARD	STUD. ØUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
AØC SCHØØL	204.5	22.9	1.9		
ENVIRØ INDØC	135.1	34.0	0.9		
PRIMARY	256.1	52.3	5.6	4.08	3.36
BASIC JET-A	305.1	20.1	1.9	4.60	3.67
BASIC JET-B	183.1	21.1	0.7	4.46	3.62
B-JET G/CQ	159.8	18.1	0.5	3.65	2.96
ADV JET-TF	166.4	8.8	0.4	3.94	2.60
ADV JET-TA	217.9	9.6	0.5	4.80	2.72
BASIC PRØP	239.5	13.5	2.9	3.43	2.79
B-PRØP CQ	41.7	13.9	0.1	1.98	1.29
ADV PRØP	257.3	16.1	0.3	3.99	2.55
BASIC HELØ	289.9	10.6	2.7	4.69	4.22
PRE HELØ	42.1	10.5	0.0	3.97	4.17
HELØ PRIM	31.5	10.5	0.0	2.30	1.91
HELØ ADV	77.6	11.1	0.0	3.56	3.05

TABLE 3.8

DYNAMIC MODEL OUTPUT
PROBLEM 2—STATUS OF ALL TRAINING PHASES

End of Second Quarter FY 1972

WEEKS 37 TØ 37

TRAINING PHASE	STUD. ØNBØARD	STUD. ØUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
AØC SCHØØL	203.7	22.8	1.9		
ENVIRØ INDØC	134.6	33.9	0.9		
PRIMARY	254.2	50.7	5.5	5.00	4.11
BASIC JET-A	314.9	19.1	1.9	4.60	3.67
BASIC JET-B	162.1	20.1	0.6	4.46	3.62
B-JET G/CQ	194.9	17.7	0.6	3.65	2.96
ADV JET-TF	160.3	6.8	0.4	4.19	2.76
ADV JET-TA	225.1	7.0	0.5	4.80	2.72
BASIC PRØP	205.4	11.5	2.5	3.39	2.76
B-PRØP CQ	34.8	11.6	0.1	1.79	1.17
ADV PRØP	227.4	14.2	0.3	5.00	3.20
BASIC HELØ	337.0	9.5	3.2	4.69	4.22
PRE HELØ	39.6	9.9	0.0	4.16	4.37
HELØ PRIM	30.6	10.2	0.0	2.79	2.33
HELØ ADV	73.7	10.5	0.0	4.10	3.50

End of Third Quarter FY 1972

WEEKS 50 TØ 50

TRAINING PHASE	STUD. ØNBØARD	STUD. ØUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
AØC SCHØØL	203.6	22.8	1.9		
ENVIRØ INDØC	134.5	33.9	0.9		
PRIMARY	281.0	51.4	6.0	5.00	4.11
BASIC JET-A	351.0	19.3	2.1	4.60	3.67
BASIC JET-B	143.5	20.4	0.5	4.46	3.62
B-JET G/CQ	217.7	15.0	0.7	3.65	2.96
ADV JET-TF	145.1	7.7	0.4	3.86	2.54
ADV JET-TA	221.7	8.6	0.5	4.80	2.72
BASIC PRØP	186.0	10.5	2.3	2.85	2.32
B-PRØP CQ	30.8	10.3	0.1	1.57	1.02
ADV PRØP	198.6	12.4	0.2	3.44	2.20
BASIC HELØ	382.1	9.5	3.6	4.69	4.22
PRE HELØ	37.2	9.3	0.0	3.90	4.09
HELØ PRIM	27.5	9.2	0.0	2.48	2.06
HELØ ADV	66.4	9.5	0.0	3.65	3.12

TABLE 3.9

DYNAMIC MODEL OUTPUT
PROBLEM 2—STATUS OF ALL TRAINING PHASES

End of Fourth Quarter FY 1972

WEEKS 63 TØ 63

TRAINING PHASE	STUD. ØNBØARD	STUD. ØUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
AØC SCHØØL	203.5	22.8	1.9		
ENVIRØ INDØC	134.5	33.9	0.9		
PRIMARY	252.8	51.7	5.5	4.18	3.43
BASIC JET-A	350.6	21.1	2.1	4.60	3.67
BASIC JET-B	143.4	20.6	0.5	4.14	3.36
B-JET G/CQ	242.0	18.1	0.7	3.65	2.96
ADV JET-TF	144.8	7.6	0.4	3.51	2.31
ADV JET-TA	222.9	9.4	0.5	4.80	2.72
BASIC PRØP	185.8	10.4	2.3	2.63	2.14
B-PRØP CQ	30.3	10.1	0.1	1.42	0.92
ADV PRØP	179.8	11.2	0.2	2.82	1.80
BASIC HELØ	421.9	10.2	3.9	4.69	4.22
PRE HELØ	41.1	10.3	0.0	4.02	4.21
HELØ PRIM	30.5	10.2	0.0	2.30	1.92
HELØ ADV	67.7	9.7	0.0	3.15	2.69

End of First Quarter FY 1973

WEEKS 76 TØ 76

TRAINING PHASE	STUD. ØNBØARD	STUD. ØUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
AØC SCHØØL	203.5	22.8	1.9		
ENVIRØ INDØC	134.5	33.9	0.9		
PRIMARY	250.8	51.3	5.5	4.00	3.29
BASIC JET-A	332.4	20.1	2.0	4.60	3.67
BASIC JET-B	145.8	20.9	0.5	4.41	3.58
B-JET G/CQ	261.6	18.1	0.8	3.65	2.96
ADV JET-TF	148.4	7.8	0.4	3.52	2.32
ADV JET-TA	220.8	9.6	0.5	4.80	2.72
BASIC PRØP	182.6	10.3	2.2	2.62	2.13
B-PRØP CQ	29.8	9.9	0.0	1.41	0.92
ADV PRØP	170.1	10.6	0.2	2.64	1.69
BASIC HELØ	447.1	10.6	4.2	4.69	4.22
PRE HELØ	42.1	10.5	0.0	3.98	4.17
HELØ PRIM	31.5	10.5	0.0	2.30	1.92
HELØ ADV	71.9	10.3	0.0	3.30	2.82

TABLE 3.10

PROBLEM 2—SAMPLE PROBLEM AREAS

Last Week in Time Period	Simulation Week	Student Load	Student Output	Aircraft Utilization	Introduction Utilization
Basic Helo Training Phase					
FY 1971	11	234.9	10.2	4.69	4.22
First Quarter, 1972	24	289.9	10.6	4.69	4.22
Second Quarter, 1972	37	337.0	9.5	4.69	4.22
Third Quarter, 1972	50	382.1	9.5	4.69	4.22
Fourth Quarter, 1972	63	421.9	10.2	4.69	4.22
First Quarter, 1973	76	447.1	10.6	4.69	4.22
Advanced Prop Training Phase					
FY 1971	11	264.4	16.5	4.15	2.65
First Quarter, 1972	24	257.3	16.1	3.99	2.55
Second Quarter, 1972	37	227.4	14.2	5.00	3.20
Third Quarter, 1972	50	198.6	12.4	3.44	2.20
Fourth Quarter, 1972	63	179.8	11.2	2.82	1.80
First Quarter, 1973	76	170.1	10.6	2.64	1.69

of students through FY 1972 and FY 1973 with the desired student output in both years. The Static IFRS planning tool was used to calculate aircraft and instructor requirements. These new data were entered into the Current Status module as shown in Table 3.11. In this example, the MIX is the same as in Problem 2. Next the manager selects the period of analysis to be weeks 1 through 115 as in the previous example. The manager analyzed this problem on a quarterly basis and the computer printouts for the end of each quarter are shown in Tables 3.12-3.14. These new end-of-quarter status reports indicate a more even flow of students without excessive student backlogs or underutilization of resources.

3.15 Since the student flows appear to be even in this example, the manager decided to have the average weekly output printed for each quarter which includes the average number of students graduating each week of the 13-week quarter. Furthermore, he was interested in the terminal phases and so requested the four terminal phases appearing in Table 3.15. These same student outputs when multiplied by the 13 weeks result in a total annual PTR of 2,233 or 67 short of the desired 2,300 as shown in Table 3.15.

3.16 There are various reasons why this FY 1973 PTR of 2,233 does not equal the one entered (i.e., 2,300). The 2,300 PTR was based solely on standard attrition rates and length of training. This student flow module accounts for many more variables such as aircraft and instructor availability, utilization, inventory, monthly weather factors, etc. Thus the problem of having 67 fewer than desired students in the year is one of managing the pilot training program and not of having too few students entering the system. Thus the manager must continue to make minor changes in the training program to arrive at his desired goal of 2,300 students.

3.17 However, note that this Dynamic model is estimating expected FY 1973 information during FY 1971. Thus the manager should use this run as a plan or control device. When actual data become available, he can determine where changes should be made. The next example illustrates how the manager can use the Shock module to analyze short-range changes to the pilot training program.

PROBLEM 4—ANALYZE SHORT-RANGE CHANGES IN TRAINING PROGRAM OPERATIONS

3.18 This example illustrates several of the "shock" capabilities of the Dynamic model. It is expected that this Shock module will be used for short- rather than long-range planning purposes. As a point of departure, these examples use those data in Problem 3 as a starting point.

TABLE 3.11

PROBLEM 3—DATA INPUT TO CURRENT STATUS MODULE

	* PHASE NAME	*AIRCRAFT TYPES *	VALUES
1	AØC SCHØØL		?200,15,0,0
2	ENVIRØ INDØC		?84,32,0,0
3	PRIMARY	T34B	?450,95,109,136
4	BASIC JET-A	T-2A	?250,18,100,128
5	BASIC JET-B	T2BC	?228,10,103,101
6	B-JET G/CQ	T2BC	?81,28,59,45
7	ADV JET-TF	TF9J	?189,37,153,150
8	ADV JET-TA	TA4J	?213,47,165,175
9	BASIC PROP	T28C	?375,16,101,94
10	B-PRØP CQ	T28C	?70,17,14,8
11	ADV PRØP	TS2A	?225,10 86,103
12	BASIC HELØ	T28C	?143,6,132,123
13	PRE HELØ	T28C	?35,8,22,27
14	HELØ PRIM	TH57	?80,12,27,30
15	HELØ ADV	TH1L	?100,8,68,76

	* PHASE NAME	*A/C *TYPE	*STUDENTS* *ON BØARD*	STUDENT* ØUTPUT	NUMBER * *AIRCRAFT*	NUMBER * INSTRS *
1	AØC SCHØØL		200.0	15.0	0.0	0.0
2	ENVIRØ INDØC		84.0	32.0	0.0	0.0
3	PRIMARY	T34B	450.0	95.0	109.0	136.0
4	BASIC JET-A	T-2A	250.0	18.0	100.0	128.0
5	BASIC JET-B	T2BC	228.0	10.0	103.0	101.0
6	B-JET G/CQ	T2BC	81.0	28.0	59.0	45.0
7	ADV JET-TF	TF9J	189.0	37.0	153.0	150.0
8	ADV JET-TA	TA4J	213.0	47.0	165.0	175.0
9	BASIC PRØP	T28C	375.0	16.0	101.0	94.0
10	B-PRØP CQ	T28C	70.0	17.0	14.0	8.0
11	ADV PRØP	TS2A	225.0	10.0	86.0	103.0
12	BASIC HELØ	T28C	143.0	6.0	132.0	123.0
13	PRE HELØ	T28C	35.0	8.0	22.0	27.0
14	HELØ PRIM	TH57	80.0	12.0	27.0	30.0
15	HELØ ADV	TH1L	100.0	8.0	68.0	76.0

TABLE 3.12

DYNAMIC MODEL OUTPUT
PROBLEM 3—STATUS OF ALL TRAINING PHASES

End of FY 1971

WEEKS 11 TO 11

TRAINING PHASE	STUD. ONBOARD	STUD. OUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
AOC SCHOOL	207.2	23.2	1.9		
ENVIRO INDOC	136.1	34.3	0.9		
PRIMARY	333.9	57.0	7.1	4.99	4.18
BASIC JET-A	265.2	22.7	1.6	4.60	3.70
BASIC JET-B	213.0	22.8	0.8	4.46	3.69
B-JET G/CQ	109.0	20.5	0.4	3.65	3.21
ADV JET-TF	180.6	9.4	0.4	4.53	2.76
ADV JET-TA	206.4	10.9	0.5	4.54	2.61
BASIC PROP	358.8	11.1	4.3	4.69	4.22
B-PROP CQ	68.9	11.4	0.1	3.56	3.14
ADV PROP	232.3	11.9	0.3	5.21	3.62
BASIC HELO	211.8	12.6	2.0	3.51	3.17
PRE HELO	44.6	11.2	0.0	3.37	3.21
HELO PRIM	34.1	11.4	0.0	3.62	3.14
HELO ADV	94.1	13.5	0.1	4.44	3.44

End of First Quarter FY 1972

WEEKS 24 TO 24

TRAINING PHASE	STUD. ONBOARD	STUD. OUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
AOC SCHOOL	204.5	22.9	1.9		
ENVIRO INDOC	135.1	34.0	0.9		
PRIMARY	261.8	53.5	5.7	4.52	3.79
BASIC JET-A	265.1	21.6	1.6	4.60	3.70
BASIC JET-B	201.9	21.8	0.7	4.46	3.69
B-JET G/CQ	133.0	20.5	0.4	3.65	3.21
ADV JET-TF	176.8	9.3	0.4	4.38	2.67
ADV JET-TA	208.6	11.0	0.5	4.49	2.58
BASIC PROP	337.5	10.9	4.0	4.69	4.22
B-PROP CQ	63.0	11.3	0.1	3.56	3.14
ADV PROP	224.0	12.0	0.3	5.21	3.62
BASIC HELO	242.8	14.4	2.3	3.88	3.51
PRE HELO	55.1	13.8	0.1	4.02	3.84
HELO PRIM	39.1	13.1	0.1	4.02	3.49
HELO ADV	86.6	12.4	0.0	4.04	3.13

TABLE 3.13

PROBLEM 3—STATUS OF ALL TRAINING PHASES

End of Second Quarter FY 1972

WEEKS 37 TØ 37

TRAINING PHASE	STUD. ØNBØARD	STUD. ØUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
AØC SCHØØL	203.7	22.8	1.9		
ENVIRØ INDØC	134.6	33.9	0.9		
PRIMARY	271.5	46.7	5.8	4.99	4.18
BASIC JET-A	255.8	20.5	1.6	4.60	3.70
BASIC JET-B	191.2	20.7	0.7	4.46	3.69
B-JET G/CQ	146.7	20.0	0.5	3.65	3.21
ADV JET-TF	177.4	7.0	0.4	4.53	2.76
ADV JET-TA	212.1	8.5	0.5	4.80	2.76
BASIC PRØP	305.5	9.5	3.6	4.69	4.22
B-PRØP CQ	52.5	10.4	0.1	3.56	3.14
ADV PRØP	236.3	8.5	0.3	5.21	3.62
BASIC HELØ	239.6	14.2	2.3	4.26	3.86
PRE HELØ	58.9	14.0	0.1	4.54	4.33
HELØ PRIM	47.0	12.8	0.1	4.94	4.29
HELØ ADV	92.9	13.1	0.1	5.17	4.01

End of Third Quarter FY 1972

WEEKS 50 TO 50

TRAINING PHASE	STUD. ONBOARD	STUD. OUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
AOC SCHOOL	203.6	22.8	1.9		
ENVIRO INDOC	134.5	33.9	0.9		
PRIMARY	339.3	47.4	7.0	4.99	4.18
BASIC JET-A	259.9	20.8	1.6	4.60	3.70
BASIC JET-B	180.4	21.0	0.7	4.46	3.69
B-JET G/CQ	152.3	17.1	0.5	3.65	3.21
ADV JET-TF	167.6	8.6	0.4	4.53	2.76
ADV JET-TA	200.6	10.5	0.5	4.80	2.76
BASIC PROP	277.0	10.2	3.3	4.69	4.22
B-PROP CQ	39.3	10.5	0.1	3.56	3.14
ADV PROP	243.4	10.8	0.3	5.21	3.62
BASIC HELO	224.1	13.3	2.2	3.99	3.61
PRE HELO	63.4	14.0	0.1	4.54	4.33
HELO PRIM	53.0	13.0	0.1	4.94	4.29
HELO ADV	89.9	12.8	0.1	5.01	3.88

TIME OUTPUT DESIRED(Y,N)?

TABLE 3.14

PROBLEM 3—STATUS OF ALL TRAINING PHASES

End of Fourth Quarter FY 1972

WEEKS 63 TØ 63

TRAINING PHASE	STUD. ØNBØARD	STUD. ØUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
AØC SCHØØL	203.5	22.8	1.9		
ENVIRØ INDØC	134.5	33.9	0.9		
PRIMARY	274.6	56.1	6.0	4.91	4.11
BASIC JET-A	254.8	22.7	1.6	4.60	3.70
BASIC JET-B	166.5	22.8	0.6	4.46	3.69
B-JET G/CQ	177.3	20.5	0.6	3.65	3.21
ADV JET-TF	166.0	8.8	0.4	4.21	2.56
ADV JET-TA	200.5	10.6	0.5	4.41	2.53
BASIC PRØP	259.1	11.1	3.1	4.69	4.22
B-PRØP CQ	32.8	11.0	0.1	3.41	3.00
ADV PRØP	244.8	11.9	0.3	5.21	3.62
BASIC HELØ	244.4	14.5	2.4	4.05	3.66
PRE HELØ	56.3	14.1	0.1	4.25	4.06
HELØ PRIM	44.1	14.7	0.1	4.69	4.07
HELØ ADV	102.0	14.6	0.1	4.81	3.73

End of First Quarter FY 1973

WEEKS 76 TØ 76

TRAINING PHASE	STUD. ØNBØARD	STUD. ØUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
AØC SCHØØL	203.5	22.8	1.9		
ENVIRØ INDØC	134.5	33.9	0.9		
PRIMARY	252.3	51.6	5.5	4.36	3.65
BASIC JET-A	242.9	21.6	1.5	4.60	3.70
BASIC JET-B	156.3	21.8	0.6	4.46	3.69
B-JET G/CQ	189.9	20.5	0.6	3.65	3.21
ADV JET-TF	169.3	8.9	0.4	4.19	2.55
ADV JET-TA	205.7	10.9	0.5	4.43	2.54
BASIC PRØP	237.9	10.9	2.9	4.69	4.22
B-PRØP CQ	32.2	10.8	0.1	3.39	2.99
ADV PRØP	230.4	12.0	0.3	5.21	3.62
BASIC HELØ	246.8	14.7	2.4	3.95	3.57
PRE HELØ	58.4	14.6	0.1	4.26	4.07
HELØ PRIM	43.4	14.5	0.1	4.46	3.87
HELØ ADV	100.8	14.4	0.1	4.70	3.64

TABLE 3.15

DYNAMIC MODEL OUTPUT
PROBLEM 3—AVERAGE QUARTERLY INFORMATION
FOR TERMINAL PHASES

First Quarter FY 1973

WEEKS 64 TO 76

TRAINING PHASE	STUD. ONBOARD	STUD. OUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
ADV JET-TF	168.7	8.9	0.4	4.06	2.47
ADV JET-TA	204.4	10.8	0.5	4.27	2.45
ADV PROP	236.7	12.2	0.3	5.21	3.62
HELO ADV	101.2	14.5	0.1	4.67	3.62

Second Quarter FY 1973

WEEKS 77 TO 89

TRAINING PHASE	STUD. ONBOARD	STUD. OUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
ADV JET-TF	170.0	8.4	0.4	4.38	2.67
ADV JET-TA	206.9	10.2	0.5	4.64	2.67
ADV PROP	229.3	10.6	0.3	5.21	3.62
HELO ADV	101.2	14.0	0.1	4.89	3.79

Third Quarter FY 1973

WEEKS 90 TO 102

TRAINING PHASE	STUD. ONBOARD	STUD. OUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
ADV JET-TF	153.8	7.7	0.4	4.38	2.67
ADV JET-TA	187.8	9.4	0.5	4.65	2.67
ADV PROP	231.3	9.5	0.3	5.21	3.62
HELO ADV	96.0	13.0	0.1	5.17	4.01

Fourth Quarter FY 1973

WEEKS 103 TO 115

TRAINING PHASE	STUD. ONBOARD	STUD. OUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
ADV JET-TF	149.1	7.9	0.4	4.15	2.53
ADV JET-TA	182.1	9.6	0.5	4.40	2.53
ADV PROP	220.2	10.5	0.3	5.21	3.62
HELO ADV	95.7	13.7	0.1	4.95	3.84

FY 1973 TOTAL STUDENT OUTPUT BY QUARTER

	Quarter				
Type Pilot	1	2	3	4	Total
Jet	256	242	223	228	949
Prop	159	138	124	136	557
Helo	188	182	169	178	727
Total	603	562	516	542	2,233

Severe Inclement Weather Hits a Base

3.19 Assume severe inclement weather (e.g., a hurricane) forces both the Basic Jet A and Basic Jet B training phases to encounter a 10% weather factor in weeks 3 and 4 of the simulation run. The decision-maker can enter this shock into the Dynamic model by entering those data underlined in Table 3.16. The 3, 4, 11 indicates week 3, phase 4 and shock variable 11 which is weather. The shock value for weather, .10, is then entered.

3.20 He analyzes these results, and then wants to know if he can decrease the student loads by increasing the aircraft and instructor utilization by about 30% in both Basic Jet A and B in weeks 5 and 6. To illustrate the printouts of this example, each of the three phases is shown separately in Table 3.17. The top printout illustrates the results based on the standard planning factors. The middle chart illustrates the results of the bad weather. The lower chart shows how the increased utilizations affect the results. Note in each printout, only the weeks of interest are printed.

3.21 Basic Jet A Printouts. For the Basic Jet A phase as shown in Table 3.17 the student output dropped to 2.7 during the inclement weather period while the student load increased by about 40 to 302.8. This increase in student load is due to the new students who entered this phase from Primary in weeks 3 and 4 at a time when few students were leaving.

3.22 This student load remained high through the end of FY 1971, since the student output in weeks 5 through 11 is the same in both the standard and the poor weather example. This is true since both aircraft and instructors were at standard utilization rates of 4.60 and 3.70 respectively as shown. The increased utilization results in a higher student output in weeks 5 and 6 and a resulting lower student load (i.e., about 7 less) in weeks 7 through 11. However, the student load continues to be about 30 more than should be in week 11 (i.e., 296 versus 265).

3.23 Basic Jet B Printouts. These same shock values affect the Basic Jet B differently as shown in Table 3.18. Students leaving Basic Jet A flow into Basic Jet B, thus the 2 weeks of inclement weather lowered the input to Basic Jet B in weeks 4 and 5 to 2.7 and thus no excessive long-term buildup of students occurred. However, the student load did build up in week 3, since the normal number of students graduated in week 2 from Basic Jet A and thus there was a 2-week surge in student load in Basic Jet B which quickly dropped back to the standard values by week 5. If the aircraft and instructor utilization are increased in weeks 5 and 6, the student output is increased in those 2 weeks and the student load in week 11 is less than that based on standard planning factors (i.e., 207.9 versus 213.0).

3.24 Basic Jet G/CQ Phase Printout. The training phase was not directly affected by the bad weather; however, since all Basic Jet B students flow into this phase, there is a delayed effect in this phase as shown by the printouts in Table 3.19 . The first week of this phase to be affected was week 4 as shown (i.e., student load is 73.3 rather than 89.4). Note the student loads and also the utilization rates between weeks 4 and 11 are less. When phases 4 and 5 increase utilizations, the Basic Jet G/CQ phase in week 6 will be affected. The result is a gradual buildup of student loads and utilization.

3.25 Based on these printouts, a bottleneck remains in the Basic Jet A phase. The manager can continue to analyze alternative courses of action to see what he can do to eliminate this bottleneck.

Force Student Input and Output in Advanced Jet TA-4J Phase

3.26 Assume that the Advanced Jet TA-4J phase of training must absorb 11 students from the Basic Prop CQ phase in week 7, and in order to meet FY 1971 student output requirements, 20 students must graduate in week 11 rather than 10.5. These changes are entered into the shock module and the resultant printouts appear in Table 3.20. The top block shows the model output based on the standard planning factors and flow process. The second block shows what happens when 11 new students enter in week 7 (i.e., total input was 20) and 20 students are forced to graduate in week 11. Essentially the student load increases between weeks 7 and 10 as shown. To graduate the 20 students in week 11, requires very high utilizations with the assumption of even flow within a phase.

TABLE 3.16

PROBLEM 4—ENTER SHOCK VALUES

```
ENTER SHOCK PARAMETERS(XX,XX,XX)
TO TERMINATE SHOCK ENTER(0,0,0)?3,4,11

ENTER 1 SHOCK VALUE?0.1

ENTER SHOCK PARAMETERS(XX,XX,XX)?3,5,11

ENTER 1 SHOCK VALUE?0.1

ENTER SHOCK PARAMETERS(XX,XX,XX)?4,4,11
ENTER 1 SHOCK VALUE?0.1

ENTER SHOCK PARAMETERS(XX,XX,XX)?4,5,11
ENTER 1 SHOCK VALUE?0.1

ENTER SHOCK PARAMETERS(XX,XX,XX)?0,0,0
```

TABLE 3.17

PROBLEM 4—HOW SHOCKS AFFECT BASIC JET A PHASE

Using Standard Planning Factors

PHASE BASIC JET-A

WEEK 1	267.8	21.9	1.7	4.60	3.70
WEEK 2	266.7	21.9	1.6	4.60	3.70
WEEK 3	265.6	21.9	1.6	4.60	3.70
WEEK 4	262.9	23.5	1.6	4.60	3.70
WEEK 5	262.9	23.5	1.6	4.60	3.70
WEEK 6	262.9	23.5	1.6	4.60	3.70
WEEK 7	262.9	23.5	1.6	4.60	3.70
WEEK 8	263.7	22.7	1.6	4.60	3.70
WEEK 9	264.2	22.7	1.6	4.60	3.70
WEEK 10	264.7	22.7	1.6	4.60	3.70
WEEK 11	265.2	22.7	1.6	4.60	3.70

Poor Weather for Weeks 3 and 4

PHASE BASIC JET-A

WEEK PERIØD	STUD. ØNBØARD	STUD. ØUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
WEEK 3	284.8	2.7	1.6	4.60	3.70
WEEK 4	302.8	2.7	1.7	4.60	3.70
WEEK 5	302.6	23.5	1.9	4.60	3.70
WEEK 6	302.4	23.5	1.9	4.60	3.70
WEEK 7	302.1	23.5	1.9	4.60	3.70
WEEK 8	302.7	22.7	1.9	4.60	3.70
WEEK 9	303.0	22.7	1.9	4.60	3.70
WEEK 10	303.3	22.7	1.9	4.60	3.70
WEEK 11	303.6	22.7	1.9	4.60	3.70

Increase Aircraft and Instructor Utilization in Weeks 5 and 6

PHASE BASIC JET-A

WEEK PERIØD	STUD. ØNBØARD	STUD. ØUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
WEEK 5	298.7	27.3	1.9	5.36	4.31
WEEK 6	295.0	27.0	1.8	5.29	4.25
WEEK 7	294.8	23.5	1.8	4.60	3.70
WEEK 8	295.4	22.7	1.8	4.60	3.70
WEEK 9	295.8	22.7	1.8	4.60	3.70
WEEK 10	296.1	22.7	1.8	4.60	3.70
WEEK 11	296.4	22.7	1.8	4.60	3.70

TABLE 3.18

PROBLEM 4—HOW SHOCKS AFFECT THE BASIC JET B PHASE

Using Standard Planning Factors

PHASE BASIC JET-B

WEEK 1	223.2	22.0	0.8	4.46	3.69
WEEK 2	222.2	22.0	0.8	4.46	3.69
WEEK 3	221.2	22.0	0.8	4.46	3.69
WEEK 4	218.7	23.6	0.8	4.46	3.69
WEEK 5	217.8	23.6	0.8	4.46	3.69
WEEK 6	216.9	23.6	0.8	4.46	3.69
WEEK 7	215.9	23.6	0.8	4.46	3.69
WEEK 8	215.8	22.8	0.8	4.46	3.69
WEEK 9	214.9	22.8	0.8	4.46	3.69
WEEK 10	213.9	22.8	0.8	4.46	3.69
WEEK 11	213.0	22.8	0.8	4.46	3.69

Poor Weather for Weeks 3 and 4

PHASE BASIC JET-B

WEEK 3	240.6	2.6	0.8	4.46	3.69
WEEK 4	239.9	2.6	0.8	4.46	3.69
WEEK 5	218.2	23.6	0.8	4.46	3.69
WEEK 6	217.2	23.6	0.8	4.46	3.69
WEEK 7	216.3	23.6	0.8	4.46	3.69
WEEK 8	216.2	22.8	0.8	4.46	3.69
WEEK 9	215.2	22.8	0.8	4.46	3.69
WEEK 10	214.3	22.8	0.8	4.46	3.69
WEEK 11	213.4	22.8	0.8	4.46	3.69

Increase Aircraft and Instructor Utilization in Weeks 5 and 6

PHASE BASIC JET-B

WEEK 5	211.4	30.3	0.8	5.73	4.75
WEEK 6	208.1	29.8	0.8	5.64	4.67
WEEK 7	210.8	23.6	0.8	4.46	3.69
WEEK 8	210.6	22.8	0.8	4.46	3.69
WEEK 9	209.7	22.8	0.8	4.46	3.69
WEEK 10	208.8	22.8	0.8	4.46	3.69
WEEK 11	207.9	22.8	0.8	4.46	3.69

TABLE 3.19

PROBLEM 4—HOW SHOCKS AFFECT THE BASIC JET G/CQ PHASE

Using Standard Planning Factors

PHASE B-JET G/CQ

WEEK 1	75.6	15.2	0.3	3.02	2.66
WEEK 2	81.0	16.3	0.3	3.24	2.85
WEEK 3	85.6	17.2	0.3	3.42	3.01
WEEK 4	89.4	17.9	0.3	2.97	2.62
WEEK 5	93.8	18.8	0.3	3.12	2.75
WEEK 6	97.5	19.6	0.3	3.24	2.85
WEEK 7	100.6	20.2	0.3	3.34	2.94
WEEK 8	103.3	20.5	0.4	3.65	3.21
WEEK 9	105.2	20.5	0.4	3.65	3.21
WEEK 10	107.1	20.5	0.4	3.65	3.21
WEEK 11	109.0	20.5	0.4	3.65	3.21

Poor Weather for Weeks 3 and 4

PHASE B-JET G/CQ

WEEK 3	85.6	17.2	0.3	3.42	3.01
WEEK 4	73.3	14.7	0.3	2.44	2.15
WEEK 5	63.0	12.6	0.2	2.10	1.85
WEEK 6	71.9	14.4	0.2	2.39	2.11
WEEK 7	79.3	15.9	0.3	2.64	2.32
WEEK 8	85.5	17.2	0.3	3.05	2.68
WEEK 9	89.9	18.0	0.3	3.21	2.82
WEEK 10	93.6	18.8	0.3	3.34	2.94
WEEK 11	96.7	19.4	0.3	3.45	3.04

Increase Aircraft and Instructor Utilization in Weeks 5 and 6

PHASE B-JET G/CQ

WEEK 5	63.0	12.6	0.2	2.10	1.85
WEEK 6	77.5	15.6	0.3	2.58	2.27
WEEK 7	89.2	17.9	0.3	2.97	2.61
WEEK 8	93.6	18.8	0.3	3.34	2.94
WEEK 9	96.7	19.4	0.3	3.45	3.04
WEEK 10	99.3	19.9	0.3	3.54	3.12
WEEK 11	101.4	20.3	0.3	3.61	3.18

TABLE 3.20

PROBLEM 4—HOW SHOCKS AFFECT THE ADVANCED JET-TA PHASE

Using Standard Planning Factors

PHASE ADV JET-TA

WEEK 5	207.1	10.9	0.5	4.72	2.71
WEEK 6	202.9	10.7	0.5	4.62	2.65
WEEK 7	200.4	10.6	0.5	4.56	2.62
WEEK 8	199.2	10.5	0.5	4.38	2.52
WEEK 9	198.6	10.5	0.5	4.37	2.51
WEEK 10	198.3	10.5	0.5	4.36	2.51
WEEK 11	198.3	10.5	0.5	4.36	2.51

Shocking Student Input and Output

PHASE ADV JET-TA

WEEK PERIØD	STUD. ØNBØARD	STUD. ØUTPUT	ATTRITES	AIRCRAFT UTIL.	INSTR. UTIL.
WEEK 7	211.2	11.1	0.5	4.80	2.76
WEEK 8	209.5	11.1	0.5	4.61	2.65
WEEK 9	208.3	11.0	0.5	4.58	2.63
WEEK 10	207.5	10.9	0.5	4.57	2.62
WEEK 11	198.0	20.0	0.5	8.34	4.79

IV. CONCLUSION

4.1 The Dynamic model as described in this report is programmed and operational on a time-sharing computer system. The model rapidly and economically provides relevant planning information at the time-share terminal. Much of this information was previously unavailable to the manager and thus it is imperative that he understands exactly what the model does and does not do. The model does not make decisions for management, but it does provide the analytic framework that facilitates the identification of feasible solutions to operational problems of the pilot training program. For instance, it can be used to establish control points required for an even annual flow of pilots, to calculate student input requirements, etc. The manager should study the examples in Section III of this report which are indicative of the types of problems that can be analyzed with the Dynamic planning tool.

BENEFITS OF THE DYNAMIC PLANNING TOOL

4.2 In particular, the use of the Dynamic planning tool by Navy decision-makers will benefit the pilot training program by contributing to better management in the following ways:

- It will provide the capability to test and analyze the consequences of alternative decisions prior to implementing a course of action.
- It will provide the planning information (i.e., not just more data) that is relevant to the particular problem.
- The information will be available (via time-sharing) to management in time to be incorporated in the decision-making process.

- It will provide a common basis for comparing the relevant features of alternatives.
- It will free management from making voluminous routine calculations manually.
- It will permit management to evaluate a large set of alternatives in great depth.

APPENDIX

DYNAMIC PLANNING TOOL FUNCTIONAL RELATIONSHIPS

A.1 The purpose of this appendix is to delineate the functional relationships employed, the assumptions made and the planning factors used in the development of the dynamic management planning tool. In general these equations were developed from those in the Logistics Support Requirements module of the Static IFRS planning tool and modified as necessary.[1] The basic assumption of an even student flow within a phase was necessary for the development of this model. Thus, for example, for a 10-week phase, essentially each student receives 10% of his training each week and 10% graduate each week if there are adequate aircraft and instructors available.

FUNCTIONAL RELATIONSHIPS

Student Input Module Equations

A.2 The student input module calculates the number of students who should enter the training program in order to ensure that the proper number of students are available to graduate with an even flow throughout each phase. The equations employed in this module are identical to those used in the Static IFRS model. The student output entered into the terminal phases is used to calculate the student input to each terminal phase. Since the phases are serially linked for each student source, the input to phase i is equal to the output of the preceding phase assuming no attrition occurs between phases. The student inputs and outputs of each phase are calculated until the student input to the entry phases is calculated. Equations (A.1) and (A.2) are used to calculate the student input and student outputs.

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[1] See Integrated Facilities Requirements Study, Phase I—Development of the Two Model System, TR 520, 5 December 1968, and Development of a Preliminary Automated Total Systems Model for the Integrated Facilities Requirements Study (IFRS) Phase II, Vol. I, TR 583, 9 February 1970, for a detailed discussion of the Static IFRS equations.

$$SI^k_{i,j} = \frac{SO^k_{i,\,j+l-1}}{(1-ATR^k_i)} \tag{A.1}$$

$$SO^k_{x,j} = SI^k_{i,j} \text{ (for all i immediately following x)} \tag{A.2}$$

where

$SI^k_{i,j}$ = student input of source k required in phase i, in week j

$SO^k_{i,j+l-1}$ = student output of source k, in phase i, in week j+l-1

ATR^k_i = percentage of students of source k who will attrite in phase i

l = number of weeks required to complete phase i

i = phase number

j = simulation week number

k = student source

x = phase preceding phase i in the flow process.

The sequence of phases required for each terminal phase and student source is defined in the pipeline data file. If a particular training phase output goes to multiple phase (e.g., Primary leads to three phases),the sum of the inputs equals the previous phase output.

A.3 The total weekly student input is then the sum of all student inputs in week j. The total weekly student input by source is the sum of all students of each source entering in week j.

Student Flow Module Equations

A.4 The students flow module aggregates all student sources together and flows them through the various phases based on the pipelines that are defined in the data files. This module operates 1 week at a time over the period of the simulation run. The equations are grouped as follows:

- Student input
- Student output
- Student attrites
- Student load
- Aircraft utilization
- Instructor utilization.

A.5 Student Input Equations. The student input for the entry phases is defined in the student input module. The student input for all other phases is calculated by equation (A.3).

$$SI_{i,j} = SO_{x,j-1} \tag{A.3}$$

where

$SI_{i,j}$ = total student input to phase i in week j

$SO_{x,j-1}$ = total student output in week j-1 of phase preceding phase i

x = the phase preceding phase i in the flow process.

When students leaving one phase have an option to progress to two or more phases, this output is divided according to the percentage distribution entered by the user.

A.6 Student Output Equations. The weekly student output is defined as the minimum of the student output calculated from equation (A.4) and from each aircraft type for equations (A.5) and (A.6). The student output based on an even weekly flow within a phase is calculated by equation (A.4).

$$SO_{i,j} = \frac{SI_{i,j} + SL_{i,j-1}}{WK_i} \tag{A.4}$$

where

$SO_{i,j}$ = student output of phase i in week j

$SL_{i,j-1}$ = student load of phase i in week j-1

WK_i = length of phase i in weeks.

The student output based on the available aircraft is calculated in equation (A.5). If more than one aircraft is required per phase (i.e., $T > 1$), the minimum student output is used.

$$SO^t_{i,j} = \frac{(AC^t_{i,j})\,(APA^t_{i,j})\,(AOU^t_{i,j})\,(DSW^t_{i,j})\,(WR^t_{i,m})}{(FH^t_i)} \tag{A.5}$$

where

$AC^t_{i,j}$ = number of A-3 status aircraft of type t assigned to phase i in week j (t = 1, 2, or 3)

$APA^t_{i,j}$ = estimated percent of assigned aircraft of type t that can be maintained in operational condition in phase i and week j

$AOU^t_{i,j}$ = average daily number of hours an available aircraft of type t may be utilized for training pilots in phase i and week j assuming perfect weather

$DSW^t_{i,j}$ = number of days scheduled for flight training in phase i, week j, and aircraft type t

$WR^t_{i,j}$ = percentage of weather in month m that is flyable for aircraft type t in phase i

m = month of the year

FH^t_i = average number of type t aircraft flight hours, both overhead and syllabus, required for a student to successfully complete the i^{th} training phase.

The numerator of equation (A.5) calculates the total flight hours available for training in week j.

A.7 The student output based on the available flight instructors is calculated in equation (A.6). If more than one aircraft type is required per phase, the minimum student output is used.

$$SO_{i,j} = \frac{(IF^t_{i,j})(IPA^t_{i,j})(IFOU^t_{i,j})\ DSW^t_{i,j})(WR^t_{i,m})}{IFH^t_i} \tag{A.6}$$

where

$IF^t_{i,j}$ = number of assigned effective flight instructors for type t aircraft assigned to phase i in week j

$IPA^t_{i,j}$ = percentage of assigned effective instructors expected to be available to be scheduled to fly in week j and phase i

$IFOU^t_{i,j}$ = average daily number of hours an available instructor of type t may be utilized for training pilots in phase i and week j assuming perfect weather

IFH_i^t = number of type t instructor hours required for a student to complete the i^{th} training phase successfully.

The numerator of equation (A.6) calculates the total instructor hours available for phase i and week j. The model then takes the minimum of equations (A.4), (A.5), and (A.6) to define the actual student output.

A.8 Attrition Calculations. A weekly phase attrition rate was defined as

$$ATRW_i = 1-10^{[\log_{10}(1-ATR_i)]/WK_i}$$

where

$ATRW_i$ = percentage of student load that attrites each week from phase i

ATR_i = percentage of students who will attrite during the i^{th} training phase

WK_i = length of i^{th} training phase.

The number of weekly attrites is then

$$ATTR_{i,j} = (ATRW_{i,j})(SL_{i,j-1} + SI_{i,j}) \qquad (A.8)$$

where

$SL_{i,j-1}$ = the student load remaining in phase i at the end of week j-1.

The second term of the equation $(SL_{i,j-1} + SI_{i,j})$ equals the total student load during week j.

A.9 Student Load Calculations. The student load on board at the end of week j, $SL_{i,j}$ is calculated in equation (A.9).

$$SL_{i,j} = SL_{i,j-1} + SI_{i,j} - SO_{i,j} - ATTR_{i,j} \qquad (A.9)$$

A.10 Aircraft Utilization Calculations. Based on the actual student output at phase i in week j, the aircraft utilization for that phase and week is calculated in equation (A.10).

$$AOU^t_{i,j} = \frac{(SO_{i,j})(IFH^t_i)}{(AC^t_{i,j})(APA^t_{i,j})(DSW^t_{i,j})(WR^t_{i,m})} . \qquad (A.10)$$

Equation (A.10) is essentially the same as equation (A.6) transposed to solve for utilization. The terms of the above equation were defined previously.

A.11 Instructor Utilization Calculation. Based on the actual student output of phase i in week j, the instructor utilization is calculated as follows:

$$IFOU^t_{i,j} = \frac{(SO_{i,j})(IFH^t_i)}{(IF^t_{i,j})(IPA^t_{i,j})(DSW^t_{i,j})(WR^t_{i,m})} . \qquad (A.11)$$

Equation (A.11) is essentially the same as equation (A.7) transposed to solve for instructor utilization. All terms were defined previously.

PRESENT PLANNING FACTORS

A.12 The data presently stored in the Dynamic model data files are based on present NATRACOM planning factors and appear in Table A.1 which follows.

TABLE A.1

DATA BASE FOR THE DYNAMIC MODEL

Planning Factor	Phase Name														
	AOC School	Envir Indoc	Primary	Basic Jet-A	Basic Jet-B	B-Jet G/CQ	Adv Jet-TF	Adv Jet-TA	Basic Prop	B-Prop CQ	Adv Prop	Basic Helo	Pre-Helo	Helo Primary	Helo Adv
Phase duration, wk	10.0	5.0	6.0	12.0	8.0	6.0	20.0	20.0	19.0	4.0	17.0	18.0	5.0	4.0	8.0
Aircraft:															
No. of types	0	0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Types	—	—	T34B	T-2A	T2BC	T2BC	TF9J	TA4J	T28C	T28C	T52A	T28C	T28C	TH57	TH1L
Availability	0	0	0.84	0.77	0.75	0.72	0.64	0.65	0.79	0.79	0.715	0.79	0.84	0.66	0.57
Utilization	0	0	5.0	4.6	4.46	3.65	4.53	4.8	4.69	3.56	5.21	4.69	4.54	5.01	5.23
Hr per student	0	0	32.6	65.1	64.4	30.7	205.0	195.0	127.50	15.0	123.8	122.5	23.5	24.2	57.0
Instructors:															
Availability	0	0	0.72	0.77	0.77	0.73	0.76	0.76	0.73	0.69	0.76	0.73	0.72	0.69	0.69
Utilization	0	0	4.18	3.7	3.7	3.23	2.76	2.76	4.25	3.22	3.62	4.25	4.44	4.29	4.01
Hr per student	0	0	29.2	67.0	53.7	20.9	145.3	139.0	98.7	6.6	109.4	95.4	23.6	24.4	59.8
Fly days per week	0	0	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
Phase attrition rate	0.08	0.026	0.102	0.066	0.026	0.017	0.046	0.046	0.196	0.005	0.019	0.151	0.004	0.004	0.004
Flyable weather, %:															
January			63.0	59.0	60.0	68.0	68.0	68.0	63.0	76.0	67.0	71.0	71.0	70.0	75.0
February			65.0	63.0	65.0	67.0	79.0	79.0	65.0	78.0	76.0	77.0	77.0	71.0	75.0
March			69.0	78.0	80.0	69.0	81.0	81.0	71.0	82.0	85.0	80.0	80.0	73.0	77.0
April			75.0	82.0	84.0	74.0	81.0	81.0	76.0	88.0	83.0	87.0	87.0	79.0	83.0
May			84.0	88.0	90.0	89.0	86.0	86.0	82.0	88.0	89.0	91.0	91.0	87.0	91.0
June			83.0	85.0	87.0	83.0	89.0	89.0	77.0	89.0	94.0	86.0	86.0	87.0	91.0
July			87.0	90.0	92.0	89.0	95.0	95.0	81.0	89.0	97.0	92.0	92.0	89.0	93.0
August			83.0	91.0	94.0	85.0	95.0	95.0	80.0	90.0	97.0	89.0	89.0	90.0	94.0
September			86.0	81.0	83.0	83.0	91.0	91.0	76.0	88.0	95.0	89.0	89.0	90.0	92.0
October			88.0	86.0	89.0	89.0	90.0	90.0	86.0	95.0	94.0	91.0	91.0	91.0	95.0
November			75.0	75.0	76.0	71.0	87.0	87.0	73.0	88.0	87.0	85.0	85.0	81.0	86.0
December			68.0	77.0	79.0	81.0	66.0	66.0	66.0	81.0	67.0	80.0	80.0	72.0	76.0